FIVE-YEAR REVIEW REPORT

First Five-Year Review Report
for
Former Murray Smelter Superfund Site
Murray, Utah

September 2003

Prepared By:

UTAH DEPARTMENT OF ENVIRONMENTAL QUALITY
SALT LAKE CITY, UTAH
&
REGION VIII
UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
DENVER, COLORADO

Approved by:

Date

Max H. Dodson
Assistant Regional Administrator
Office of Ecosystems Protection
and Remediation

9/22/03

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Table of Contents

FIGURES

TABLES

List of Acronyms

ACL	Alternate Concentration Limit
ARARS	Applicable or Relevant and Appropriate Requirements
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
EPA	Environmental Protection Agency
HASP	Health and Safety Plan
IC	Institutional Controls
IHC	IHC Health Services
MNA	Monitored Natural Attenuation
MCLs	Maximum Contaminant Levels
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NPL	National Priorities List
O&M	Operation and Maintenance
PRP	Potentially Responsible Party
PURR	Primary Under Roadway Repository
RA	Remedial Action
RDRGSWM	Remedial Design for Groundwater and Surface Water Monitoring
RI/FS	Remedial Investigation/Feasibility Study
ROD	Record of Decision
SAP	Sampling and Analysis Plan for Groundwater and Surface Water Monitoring
SSOD	Smelter Site Overlay District
SWRE	Southwest Repository Extension
UDEQ	Utah Department of Environmental Quality
UTA	Utah Transit Authority
UTAFRE	UTA Facility Repository Extension
UTL	Upper Tolerance Limit

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Executive Summary

EPA Region 8 and the UDEQ have conducted the first five-year review of the remedial actions implemented at the Former Murray Smelter Superfund Site (Site) located in Murray, Utah. The review was conducted from May through September 2003. The results of the five-year review indicate that the remedy is expected to be protective of human health and the environment, and immediate threats have been addressed.

Overall, the repository and barrier systems are being monitored and maintained as designed. Stringent institutional controls for the Site are in place with the establishment and enforcement of the Smelter Site Overlay District. Access controls and signs are effectively in place at areas of the Site that have not been completed such as the future location of the Inter-mountain Medical Center. Contaminant levels along Site boundaries are below performance standards. Contaminant levels in shallow groundwater within Site boundaries are consistent with expectations at the time of the ROD. In addition, residents and businesses in the area are connected to the municipal water system. A few issues that do not immediately impact the protectiveness of the remedy were identified:

- Analysis of data related to the repository was found to be difficult due to the impact of preexisting conditions at the Site and data variability. The current approach in evaluating the repository system should be reevaluated.

- The MCL for arsenic was changed from .05 mg/L to .01 mg/L in January of 2001. The protectiveness of the remedy was not affected because performance standards at Site boundaries are still being met and the appropriate institutional controls on the Site are still in place. Where applicable, the modified MCL will be the performance standard and will need to be used in data evaluation.

- During baseline and detection monitoring, cadmium and lead levels were consistently found to be above MCLs in Compliance Well MW-5D. The contamination is likely due to preexisting conditions. Given these results and in accordance with the Remedial Design for Groundwater Monitoring, Alternate Concentration Limits should be evaluated for cadmium and lead for the shallow aquifer within Site boundaries as was done for arsenic. The evaluation process should begin by sampling all wells for all metals/metalloids with state groundwater standards to verify that elevated cadmium/lead levels are located only in the immediate area of MW-5D.

- Comprehensive and complete information on the status of the remedy was not readily available at the start of this five-year review. Needed information was subsequently provided by Asarco and Murray City in a timely and acceptable manner. However, Asarco and Murray City will need to provide comprehensive annual reports on their respective responsibilities in order to adequately measure the effectiveness and protectiveness of the remedy on a regular basis.

- The installation of three additional wells to monitor the effects of monitored natural attenuation was postponed due to the construction of Costco. Costco was completed in January of this year and the installation of the three wells is now required.

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Five-Year Review Summary Form

SITE IDENTIFICATION		
Site name *(from WasteLAN)*: Former Murray Smelter Superfund Site		
EPA ID *(from WasteLAN)*: UTD980951420		
Region: 8	**State:** UT	**City/County:** Murray, Utah

SITE STATUS	
NPL status: ✖ Proposed ☐ Final ☐ Deleted	
Remediation status (choose all that apply): ✖ Under Construction ✖ Operating ☐ Complete	
Multiple OUs? ☐ YES ✖ NO	**Construction completion date:** N/A
Has site been put into reuse? ✖ YES ☐ NO	

REVIEW STATUS	
Reviewing agency: ✖ EPA ✖ State ☐ Tribe ☐ Other Federal Agency	
Author name: Armando Saenz of EPA and Michael Storck of UDEQ	
Author title: Remedial Project Managers	**Author affiliation:** EPA Region 8 and UDEQ
Review period: May 2003 to September 2003	
Date(s) of site inspection: May 29, 2003	
Type of review: ✖ Statutory ☐ Policy (☐ Post-SARA ☐ Pre-Sara ☐ NPL-Removal only ☐ Non-NPL Remedial Action Site ☐ NPL State/Tribe-lead ☐ Regional Discretion)	
Review number: ✖ 1 (first) ☐ 2 (second) ☐ 3 (third) ☐ Other (specify)	
Triggering action: ✖ Actual RA Onsite Construction ☐ Actual RA Start at OU # ___ ☐ Construction Completion ☐ Previous Five-Year Review Report ☐ Other (specify)	
Triggering action date *(from WasteLAN)*: 9/30/98	
Due date *(five years after triggering action date)*: 9/30/03	

Five-Year Review Summary Form

Issues:

Issues that do not immediately impact the protectiveness of the remedy were identified. The five issues were as follows:

- **Evaluation Process for Repository.** Analysis of data related to the repository was found to be difficult due to the impact of preexisting conditions at the Site and data variability. The current approach in evaluating the repository system needs to be reevaluated.
- **Change in MCL for Arsenic.** The MCL for arsenic was changed from .05 mg/L to .01 mg/L in January of 2001. The modified MCL will need to be used in data evaluation.
- **Evaluation of ACLs for Cadmium and Lead.** During baseline and detection monitoring, cadmium and lead levels were consistently found to be above MCLs in Compliance Well MW-5D. The contamination is likely due to preexisting conditions. MW-5D is down-gradient of the repository system and south of the Creek. ACLs for the metals should be evaluated.
- **Reporting Requirements.** Comprehensive and complete information on the status of the remedy was not readily available at the start of this five-year review.
- **Addition of Three Wells for Measurement of Natural Attenuation.** Three additional wells to monitor the effects of monitored natural attenuation were required to be installed in the area now occupied by Costco. Installation of the wells was postponed due to the construction of Costco. Costco was completed in January of this year and installation of the three wells is now required.

Recommendations and Follow-up Actions:

With EPA oversight, the corresponding recommendations/follow-up actions are as follows:

- **Evaluation Process for Repository.** The reevaluation should include rigorous review of the statistical approach, frequency of groundwater sampling related to the repository and choice of indicator parameters. After three full years of data accumulation, the reevaluation should be initiated. Possible outcomes of the reevaluation could be confirmation of the efficiency/effectiveness of the current approach, modifications to the current approach or a completely different approach.
- **Change in MCL for Arsenic.** Where applicable, the modified MCL will be the performance standard and will need to be used in data evaluation.
- **Evaluation of ACLs for Cadmium and Lead.** Given sampling results and according to the RDRGSWM, ACLs should be evaluated for cadmium and lead for the shallow aquifer within Site boundaries as was done for arsenic. The evaluation process should begin by sampling all wells for all metals/metalloids with state groundwater standards to verify that elevated cadmium/lead levels are located only in the immediate area of MW-5D. Further sampling of wells for all metals/metalloids with state groundwater standards will be determined by review of the initial set of sampling results.
- **Reporting Requirements.** To adequately and regularly measure the effectiveness and protectiveness of the remedy, Asarco and Murray City should provide comprehensive and complete annual reports on their respective responsibilities to EPA and UDEQ on an annual basis. Annual reports will be due on December 31 of each year.
- **Addition of Three Wells for Measurement of Natural Attenuation.** The three additional wells to monitor the effects of monitored natural attenuation should be installed in the Costco area by the end of this year.

Protectiveness Statement(s):

The remedy at the Site is expected to be protective of human health and the environment, and immediate threats have been addressed. The repository and barrier systems are being monitored and maintained as designed. Stringent institutional controls for the Site are in place with the establishment and enforcement of the SSOD. Access controls and signs are effectively in place at areas of the Site that have not been completed such as the future location of the medical center. Contaminant levels along Site boundaries are below performance standards. Contaminant levels in shallow groundwater within Site boundaries are consistent with expectations at the time of the ROD. In addition, residents and businesses in the area are connected to the municipal water system.

Former Murray Smelter Superfund Site
First Five-Year Review Report

I. Introduction

The Environmental Protection Agency (EPA) and the Utah Department of Environmental Quality (UDEQ) have conducted a five-year review of the remedial actions implemented at the Former Murray Smelter Superfund Site (Site) located in Murray, Utah. This review was conducted from May through September 2003. This report documents the results of the review. The purpose of five-year reviews is to determine whether the remedy at a site is protective of human health and the environment. The methods, findings and conclusions of reviews are documented in five-year review reports. In addition, five-year review reports identify issues found during the review, if any, and identify recommendations to address them.

This review is required by statute. EPA must implement five-year reviews consistent with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and the National Oil and Hazardous Substances Pollution Contingency Plan (NCP). CERCLA §121(c), as amended, states:

> If the President selects a remedial action that results in any hazardous substances, pollutants, or contaminants remaining at the site, the President shall review such remedial action no less often than each five years after the initiation of such remedial action to assure that human health and the environment are being protected by the remedial action being implemented.

The NCP [Part 300.430(f)(4)(ii) of the Code of Federal Regulations (CFR)] states:

> If a remedial action is selected that results in hazardous substances, pollutants, or contaminants remaining at the site above levels that allow for unlimited use and unrestricted exposure, the lead agency shall review such action no less often than every five years after the initiation of the selected remedial action.

This is the first five-year review for the Site. Due to the fact that hazardous substances, pollutants, or contaminants remain at the Site above levels that allow for unrestricted use and unlimited exposure, another five-year review is required.

II. Background

Location

The Site is located in Murray, Utah in Salt Lake County as illustrated in Figure 1. The Site

includes the former operational areas of the Murray Smelter and adjacent Germania Smelter which are referred to as the "on-facility" area, as well as surrounding residential and commercial areas where airborne emissions from the smelters impacted the environment or where contamination in shallow groundwater may be transported in the future. These surrounding areas are referred to as the "off-facility" area.

The on-facility area is approximately 142 acres. Its boundaries are 5300 South Street to the south, State Street to the east, Little Cottonwood Creek to the north, and the west set of the Denver & Rio Grande Western railroad tracks to the west. The off-facility area is approximately 30 acres to the west of the on-facility area, approximately 106 acres south and southeast of the on-facility area, and a small area between 5200 South Street and Little Cottonwood Creek to the east of the on-facility area. The west portion of the off-facility area is bounded by Little Cottonwood Creek to the north, 300 West Street to the west, 5300 South Street to the south, and the on-facility boundary to the east. The south/southwest portion is bounded by 5300 South Street to the north and Wilson Avenue to the south. The off-facility boundaries were determined by EPA based on the results of air dispersion modeling performed in November of 1994. The purpose of the modeling was to identify the area that potentially would have received the greatest amount of deposition resulting from lead and arsenic emissions from the Murray Smelter during its operating period.

Operational History

The Germania Smelter began operations in 1872 and operated until 1902. The smelter processed lead at the rate of 180 tons a day from four blast furnaces and one reverberatory furnace. The Germania Smelter was purchased by the American Smelting and Refining Company (Asarco) in 1899 and was operated by the company until Murray Smelter began operations in 1902. It is reported that the Asarco Smelter was the largest primary lead smelter in the world at the time. The smelter processed lead and silver ores through its closing in 1950. The smelter processed 1500 tons per day with eight blast furnaces. In addition to lead, several by-product metals were also produced such as gold, silver, copper, antimony, bismuth, arsenic and cadmium. The primary by-products by volume were slag, arsenic and cadmium. Much of the slag was used as ballast for the railroads and as material for construction of freeway systems in the area. Arsenic compounds were sold for use as insecticides or to the government for war time purposes. Cadmium was used primarily as paint pigment. The operations facilities on the site included an extensive network of railroad tracks, two smoke stacks (300 feet and 455 feet in height), several blast furnaces, ore storage bins and other support facilities.

Remedial History

Based on site investigations and information on historic smelter operations, EPA identified elevated levels of metals in the surface, subsurface soils and shallow groundwater. The Site was proposed for the National Priorities List in January of 1994, but the listing was never finalized.

Asarco agreed to perform an Engineering Evaluation/Cost Analysis (EE/CA) pursuant to the terms of an Administrative Order on Consent (EPA, 1995). Asarco initiated the EE/CA with investigations performed between April 1995 and February 1996. Results of these investigations were reported and discussed in the Site Characterization Report (Hydrometrics, 1996a). Along with the Site Characterization Report, EPA issued the Baseline Risk Assessment (Weston, 1996) in August 1996.

Shortly thereafter, EPA decided to redirect what had been a Non-Time-Critical Removal Action into the remedial action framework. The requirement for an EE/CA was changed to a Feasibility Study which was completed by Asarco (MFG, 1997) in August of 1997. Subsequent to the Site Characterization Report, additional investigations of surface water (MFG, 1996, Hydrometrics, 1997a, 1997b, 1997c) and soils in the off-facility area (Hydrometrics, 1996b) were performed.

Concurrently, EPA and Murray City discussed partnership alternatives to provide the City a significant role in the remedial process and allow for rapid design and implementation of the chosen remedy. In April 1996, EPA and Murray City signed a Memorandum of Understanding creating a formal role for Murray in the assessment of potential land uses at the Site, the development of cleanup options and the implementation/enforcement of institutional controls.

To facilitate development of an acceptable remedy for the on-facility area, EPA and UDEQ initiated the formation of the Murray Smelter Working Group (Working Group) in October 1996. The Working Group included the EPA, UDEQ, Murray City, Asarco and land and business owners of the on-facility area. The purpose of the Working Group was to inform EPA about pending redevelopment plans and to provide a forum for discussing alternative cleanup strategies for the on-facility area. A commitment was made by the Work Group to integrate future remedial actions with redevelopment activities. Agreements, among the members of the Working Group, were incorporated in an Agreement in Principle signed in May of 1997.

Site Investigations

Site investigations found that metals concentrations were elevated in soils primarily due to the presence of residual smelter materials (on-facility area) and deposition of smelter air emissions during the period of operation (off-facility area). Lead and arsenic were identified as the primary contaminants of concern in the on-facility area and lead in the off-facility area.

Shallow groundwater within the on-facility area was also found to be contaminated with arsenic. The data suggested a low permeability for the shallow aquifer and high attenuation characteristics for arsenic which, in turn, suggested a correlation between elevated arsenic concentrations in groundwater and areas of residual source materials. For example, in the area near the former smelter roasting plant where most of the source material was present for at least 50 years, arsenic concentrations in groundwater, immediately underlying the area, were measured as high as 50 mg/L, but only measured 0.1 mg/L just 200 yards down-gradient of the area (Hydrometrics, 1996a).

Elevated arsenic concentrations were also measured in Little Cottonwood Creek. The investigations found that, while some of the arsenic loading could be attributed to contaminated groundwater from the Site, the majority of arsenic loading of the Creek (on the order of 90 percent) originated from a storm sewer that ran south to north along the west side of State Street. The storm sewer, packed in coarse fill, was found to provide a preferential pathway for contaminated groundwater from source areas associated with the former smelter bag-house located near the corner of State Street and 5300 South Street. In addition, the investigations identified four types of smelter material:

Category I Material. Residual smelter materials associated with the arsenic trioxide process and considered undiluted flue dust. This material contained the highest arsenic concentrations (average of approximately 140,000 mg/Kg) and was present in relatively small volumes (approximately 580 tons). Category I material was identified as posing a potential health risk and as being a major source of arsenic to shallow groundwater.

Category II Material. Residual material associated with smelter flue dust operations (blast furnace flues, bag-house, roasting plant flues and Cottrell electrostatic precipitator) and considered diluted flue dust. This material contained lower arsenic concentrations (average of approximately 9,000 mg/Kg), but was present in larger volumes (approximately 90,000 cubic yards). Category II material was identified as posing a potential health risk and as being a source of arsenic to groundwater.

Category III Material. Residual smelter material and contaminated soils that contained arsenic or lead above levels that posed a potential health risk to future site workers (arsenic greater than 1,200 mg/Kg or lead greater than 5,600 mg/Kg), but were not sources of arsenic to groundwater. Once Category II materials were removed, it was found that relatively small amounts of Category III materials were present; approximately 600 cubic yards of Category III materials were removed from the rail line area to the west and relocated to the central portion of the on-facility area.

Category IV Material. Smelter slag is present primarily in the northern portion of the on-facility area. Slag has relatively high levels of lead (typically in the range of 8,000 to 16,000 mg/Kg), but is present in a physical form (vitrified iron silicate) than limits the release of metals. Slag was therefore not identified as a source of metals to groundwater or surface water and was not a current human health risk. The slag may have potential to release metals over the long term if the vitrified material breaks down due to weathering.

III. Remedial Actions

Remedy Selection

On-facility Area. The ROD for the Site was signed on April 1, 1998. The selected remedy for the on-facility area essentially included source control and monitored natural attenuation of

groundwater. The main components of the remedy for the on-facility area were as follows:

- Category I Material. Removal of material offsite to a permitted hazardous waste treatment, storage and disposal facility;

- Category II Material. Excavation of material with screening, crushing and blending prior to placement in an on-facility repository system with site development over the repository.

- Category III Material. Removal of material from the western portion of the on-facility area and placement in an undeveloped area with access controls in place. Material to be eventually covered with the redevelopment of the on-facility area which is scheduled for completion in 2008;

- Category IV Material. Material to be eventually covered with the redevelopment of the on-facility area which is scheduled for completion in 2008;

- Groundwater. Monitored natural attenuation to address the residual groundwater contamination within and down-gradient of source areas. Natural attenuation to continue until shallow groundwater achieves the ACL for dissolved arsenic of 5.0 mg/L. The intermediate aquifer to be monitored to demonstrate continued compliance with the Maximum Contaminant Level (MCL) for dissolved arsenic of .05 mg/L (MCL changed to .01 mg/L in January of 2001);

- Surface Water. Surface water of the Little Cottonwood Creek to be monitored to ensure continued compliance with applicable water quality standards.

Off-facility Area. For the off-facility area, the ROD required removal of soil with lead levels exceeding 1200 mg/kg in individual residential yards (or with lead levels exceeding 5600 mg/kg in commercial areas) and replacement with clean fill. The excavated soil was to be used as sub-grade material during construction of the repository system.

Institutional Controls. The remedy also included institutional controls (ICs). ICs were to be in the form of a Murray City ordinance establishing an "overlay district" and restrictive easements that run with the land which prohibit the construction of new wells or use of existing wells within the on-facility area and the western and eastern portions of the off-facility area except for EPA-approved monitoring wells. The overlay district to include zoning to prevent residential and contact intensive industrial uses within the former smelter operational areas and to require maintenance of the barriers and controls on excavated subsurface material within this area.

Remedy Implementation

With input from the Working Group, Asarco prepared remedial designs (RDs) for various components of the chosen remedy. The approved designs were attached to the Remedial

Design/Remedial Action Consent Decree and Statement of Work (EPA, 1998b). Remedial action (RA) activities began in August 1998 and were completed in February 2001 in accordance with the ROD and RDs.

On-facility Area. To address the Working Group's underlying goal of integrating remedial and redevelopment activities, RA activities were performed on an accelerated schedule to meet a series of interim deadlines to facilitate redevelopment of portions of the on-facility area. A couple of the more important milestones included the following:

- Completion of the portion of the repository that formed the base for the parking lot of the Utah Transit Authority (UTA) Park-and-Ride Facility before June 1, 1999. UTA opened the facility on schedule in November 1999; and

- Completion of the portions of the repository that formed the base for the new north-south access roads before November 1999. These roads include the Cottonwood and Woodrow Streets that go through the Site.

In addition to the RA activities, a removal action was required to demolish the smelter smoke stacks in the on-facility area. The smoke stacks were demolished in August of 2000. Disposal of the smokestack debris was completed in February 2001. The completion of this removal action has also helped to redevelop portions of the Site.

Off-facility Area. In the off-facility area, soil from twelve yards (residential and commercial) with average lead concentrations greater than 1,200 mg/kg was removed and replaced with clean fill. Because no residual soil contamination was left in-place at the twelve yards, ICs are not required for the off-facility area.

ICs and Redevelopment of Site. In accordance with the ROD, Murray City created the Smelter Site Overlay District (SSOD) with the passage of Ordinance 98-07 on April 14, 1998. The SSOD established the necessary public and private ICs to protect human health and environment from the remaining contamination at the Site and to protect the integrity of current and future barriers/caps. Specifically, the SSOD prohibits the construction of new wells or use of existing wells for any purpose, includes zoning to prevent residential and contact intensive industrial uses within the former smelter operational areas and requires maintenance of the barriers/caps and controls on handling of excavated subsurface material. All current and future redevelopment activities in the on-facility area must conform to SSOD requirements.

The on-facility area of the Site is currently being redeveloped to address the surrounding community's need for access to health care, public transit and diversified economic development. IHC Health Services (IHC), owner of the majority of the on-facility area, plans to construct a hospital facility (i.e. Inter-mountain Medical Center) in the near future. UTA owns and operates the Park-and-Ride facility for light rail trains in the western portion of the on-facility area. Costco, a major retail membership warehouse club, opened in January of this year. Ash Grove

Cement, south of the UTA facility, continues to operate as a distribution facility.

IV. Operation & Maintenance

The Interim Operation & Plan (Interim O&M Plan, MFG, 2001) includes all requirements for O&M of the on-facility repository system to be implemented until Certification of Completion of the RA. RA completion will be achieved when all redevelopment and remedial activities have been completed and monitored natural attenuation has been shown to be effective (using at least 10 years of groundwater and surface water data showing that performance and compliance standards have been met). Once certification is granted, the Final O&M Plan will apply to the remedy. The Final O&M Plan will describe the long-term monitoring required to demonstrate continued compliance with performance standards for groundwater, surface water and the repository system.

O&M activities apply only to the on-facility area (i.e. Category II, III and IV materials). O&M is not required for the off-facility area. O&M does not apply to Category I material because the material was removed from the Site.

Category II Material

Category II material was excavated and placed in the repository system located in the on-facility area of the Site. The repository system was fully encapsulated and lined with geo-membrane to form the base of two new north-south access roads named Cottonwood and Woodrow Streets and a portion of the parking lot of the UTA Park-and-Ride Facility. Crushed slag and aggregate base course material with associated geo-synthetics were placed over the lining of the repository system before the new roadways and parking lot were paved by Murray City and UTA, respectively. Murray City plans to extend Cottonwood Street in the near future and, in doing so, will pave the remaining unpaved portion of the repository. The repository system includes the Primary Under Roadway Repository (PURR), the Southwest Repository Extension (SWRE Phases 1 and 2) and the UTA Facility Repository Extension (UTAFRE). See Figure 2 for details.

Generally, current O&M activities include monitoring of the repository for settlement, monitoring/maintenance of the repository barriers (new buildings, roads, sidewalks, parking lots and landscaping) and drainage system. O&M requirements for the repository system are as follows:

Monitoring of Repository for Settlement. Asarco was required to survey the long-term settlement monuments on a quarterly basis for the first year following completion of the repository system. Currently, Asarco is required to survey the monuments on a semiannual basis until stable conditions are demonstrated by the settlement monitoring data. Settlement monuments include six along the northern part of PURR and two south of the SWRE (Phase 2). For settlement beyond the expected long-term settlement of 2.5 - 3.0 inches, Asarco would be

required to address the cause(es). Monitoring would be discontinued if and when the settlement monitoring data, for at least three consecutive years, suggest stable conditions.

Inspection and Maintenance of Roadways. Murray City is required to inspect and maintain the new roadways (i.e. barriers) at the Site. Inspection and maintenance procedures for roadways are described in the SSOD and associated Pavement Management Plan. The City is required to inspect and maintain the roadways for cracks, potholes or other signs of potential problems. Inspections are required on a semiannual basis and after significant storm/seismic events in the Salt Lake Valley. In general, cracks in paved areas over the repository system require sealing with appropriate material to minimize infiltration of water to the repository. Potholes require patching with asphaltic materials as soon as possible.

Inspection and Maintenance of UTAFRE Barrier. UTA is required to inspect the ground surface (i.e. barrier) overlying the whole UTA Park-and-Ride Facility. The inspections and routine maintenance are to be conducted in accordance with its SSOD Barrier Monitoring and Maintenance Plan (UTA, 2001). After significant storm/seismic events, barriers prone to erosion are to be inspected within 24 hours (or 48 hours if on a weekend or holiday).

Asarco is responsible for maintenance of the actual UTAFRE which underlies a portion of the UTA parking lot in accordance with RD/RA CD and applicable state and/or federal regulations related to disposal of hazardous substances. If damage to the UTAFRE occurs as a result of use of the parking lot, UTA will be responsible for the required repairs.

Inspection and Maintenance of SWRE (Phase 2). Asarco and Murray City were required to inspect Phase 2 of SWRE (i.e. the unpaved portion) on a quarterly basis for the first year. Currently, Murray City is required to inspect the unpaved portion on a semiannual basis until it extends Cottonwood Street.. The City is also required to maintain the unpaved portion and will continue to do so once the street is extended and the portion paved. Inspection and maintenance procedures for roadways are described in the SSOD and associated Pavement Management Plan. See Figure 2 for details.

Inspection and Maintenance of PURR & SWRE (Phase 2) Embankments. Asarco was required to quarterly inspect the embankments of the PURR and Phase 2 of the SWRE for the first year after closure. Currently, Murray City is required to inspect the embankments on a semiannual basis until it extends Cottonwood Street and IHC Health Services completes the hospital facility. In general, eroded areas are to be addressed as specified in the SSOD and Interim O&M Plan.

Inspection and Maintenance of the Storm Water Drainage System. Murray City is required to inspect the storm water drainage system associated with the repository on a semiannual basis and after significant storm events. Maintenance is to be conducted in accordance with the City's normal maintenance program for such systems. In order to reduce percolation of water and control erosion of caps/barriers, drainage plans are required for all developments.

Murray City is also required to inspect and maintain the temporary storm water control and drainage features of Phase 2 of SWRE (i.e. the unpaved portion) until it extends Cottonwood Street. Upon completion of the extension, the City will be required to inspect and maintain the associated system as described above.

Maintenance of Repository Liner System. In the event of a breach of the repository liner system, EPA and Asarco are to be notified by Murray City and/or the UTA within 24 hours of discovery. Within the 24 hours, the entity discovering the breach (Murray and/or the UTA) are required to fence, barricade and berm the damaged liner area to prevent runoff or infiltration of precipitation into the area. The entity should also put up the appropriate sign(s) to prevent traffic and/or pedestrians from entering the area.

The damaged liner area should be structurally repaired under the supervision of a geo-synthetics inspector designated by Asarco. Once the liner has been repaired, tested and approved by the inspector, the top layer should be replaced. The base course and pavement barrier should then be replaced by UTA and/or Murray City depending on the location of the liner area.

Category III Material

Approximately 600 cubic yards of Category III material was placed on the east side of the PURR embankment adjacent in the central portion of the on-facility area. The material covers an area of approximately 0.25 acre and the top of the material is approximately 4 to 6 feet below the PURR embankment.

The material will be addressed with IHC's construction of the Inter-mountain Medical Center. The material will be covered with grading fill and overlying barriers. In accordance with the SSOD and Interim O&M Plan, a Barrier Monitoring and Management Plan will be required for the medical center.

Category IV Material

Category IV material will be addressed in the same manner as Category III material. The material will be addressed with IHC's construction of the Inter-mountain Medical Center. The material will be covered with grading fill and overlying barriers. In accordance with the SSOD and Interim O&M Plan, a Barrier Monitoring and Management Plan will be required for the medical center.

V. Groundwater and Surface Water Monitoring

The Remedial Design Report for Groundwater and Surface Water Monitoring (MFG, 1998) and Sampling and Analysis Plan for Groundwater and Surface Water Monitoring (MFG, 2000) provide the design, rationale, and protocols for monitoring of the Site. Additional details concerning monitoring can be found in the Interim O&M Plan. The overall goals of the monitoring program are to: 1) meet the regulatory requirements for groundwater monitoring of

the on-facility repository system; 2) demonstrate attainment of performance standards for groundwater and surface water; and 3) evaluate the long-term performance of natural attenuation. Groundwater and surface water monitoring will continue throughout the interim O&M period unless it is demonstrated that all performance standards for groundwater and surface water have been met.

Groundwater Monitoring for Repository

Regulatory requirements require three kinds of monitoring of the shallow aquifer for the repository system. They are baseline monitoring, detection monitoring and compliance monitoring. Four sets of paired wells and one compliance well are used during monitoring. The up-gradient wells are MW-1U, -2U, -3U and -4D and the down-gradient wells are MW-1D, -2D, -3D and -4D. The compliance well, down-gradient of the repository system and south of the Little Cottonwood Creek, is MW-5D. See Figure 3 for details.

Baseline Monitoring. An initial baseline monitoring program is required to establish groundwater conditions prior to any potential effects from the repository system. The paired wells and compliance well are sampled for ten consecutive months.

Detection Monitoring. After baseline monitoring, the repository wells are monitored on a quarterly basis to identify statistically significant changes in groundwater quality that may be attributed to releases from the repository. Indicator parameters are arsenic and sulfate.

Compliance Monitoring. Compliance monitoring is required only if the data from detection monitoring shows a statistically significant increase in one or both of the indicator parameters. Monitoring entails quarterly sampling of Compliance Well MW-5D and adding metals/metalloids with state groundwater standards to the analytical parameter list. These include arsenic, barium, cadmium, chromium, copper, lead, mercury, selenium, silver and zinc.

Groundwater Monitoring

Shallow Aquifer. Monitoring of the shallow aquifer is conducted as follows:

- Water levels are measured on a quarterly basis at three piezometers just north of Little Cottonwood Creek (Creek). Along with water level measurements of the Creek and wells just south side of the Creek, the data is used to evaluate groundwater flow north of the Creek. The piezometers are PZ-1, -2 and -3. See Figure 4.

- Three wells just south of the Creek are monitored on a quarterly basis. The data is used to compare arsenic concentrations in groundwater discharging into the Creek to the Alternate Concentration Limit (ACL) of 5 mg/L. EPA established the ACL to protect the Creek at its beneficial use which is agricultural. The three wells are SPM-3, -4 and –5. See Figure 4.

- Two wells outside and west of the on-facility area are monitored on a quarterly basis to compare arsenic concentrations in shallow groundwater leaving the Site to the MCL of 0.05 mg/L. MCL changed to .01 mg/L in January of 2001. The wells are SPM-1, SPM-2. See Figure 4.

Intermediate Aquifer. Four intermediate aquifer wells within the on-facility area are monitored on a quarterly basis to compare arsenic concentrations to the MCL. The wells are IPM-1, -2, -3 and –4. See Figure 5.

Surface Water Monitoring

The Creek is monitored on a semi-annual basis at three locations. Samples are taken during low-flow and high-flow conditions at the Creek. The three locations are SW-13 (upstream of the Site boundary), SW-15 (within the Site boundaries) and SW-5 (immediately downstream of the Site boundary). See Figure 6.

Arsenic data from SW-5 are compared to Utah's Ambient Water Quality Criteria for aquatic life (0.19 mg/L trivalent arsenic as a 4-day average, 0.36 mg/L trivalent arsenic as a 1-hour average) and Agricultural Standard (0.1 mg/L).

Monitored Natural Attenuation

Four wells within the on-facility area are currently being monitored on a semi-annual basis to evaluate the performance of natural attenuation. With time, the data will be used to describe changes in the distribution and concentration of arsenic within the shallow aquifer. The four wells are MW-1D, -2D, -3D and 104. Three additional wells will be installed in the near future to further evaluate the performance of natural attenuation - their designations will be M-10, -11 and -12. See Figure 4.

VI. Five-Year Review Process

The Former Murray Smelter Superfund Site Five-year Review was led by Armando Saenz of EPA and Michael Storck of UDEQ. The following team members assisted in the review:

- Doug Hill, Public Services Director for Murray City
- Don Robbins, Director of Environmental Services for Asarco
- Andy Koulermos, Senior Chemical Engineer for MFG, Inc. (Asarco's contractor)

The five-year review consisted of the following activities: a review of relevant documents; interviews with representatives of the Potentially Responsible Party (Asarco) and Murray City; review of O&M data; and, site visits. Notices stating that the five-year review was in progress and requesting public input was placed in The Salt Lake Tribune, Deseret Morning News and the Murray Journal. No comments from the public were received. The notice of completion of the

five-year report will also be placed in the three newspapers.

VII. Five Year Review Findings

Interviews

The following individuals were contacted by telephone as part of the five-year review:

- **Don Robbins**, Director of Environmental Services for Asarco (Interviewed 8/5/03)
- **Anne vonWellar**, Chief Building Official for Murray City (Interviewed 8/7/03)

Don Robbins. Mr. Robbins stated that the clean up has been a great success for all involved. The commitment made and held by the Work Group to integrate remedial actions with redevelopment activities appears to have addressed the interests/concerns of the various stakeholders. He is not aware of any significant issues related to the Site. He also mentioned that Murray City has been great to work with and believes the City is doing a great job in implementing the applicable ICs for the Site via the SSOD.

Anne vonWellar. Ms. VonWellar stated that the repository and subsequent barriers were very well built and that the City has not any encountered any significant problems with the remedy as a whole. The barrier system is being inspected and maintained in accordance with the SSOD, Pavement Management Plan and applicable Barrier Monitoring and Maintenance Plan(s). She explained that in the rare occasion when an SSOD permittee (i.e. property owner, developer, municipal entity) forgets to turn in the required inspection report, the City sends a letter reminding the permittee of his/her obligations under the SSOD. All permittees, receiving such letters in the past, have quickly responded with the required report. In general, past and present permittees have been very cooperative and understanding of SSOD requirements. She is also not aware of any significant issues related to the Site.

Site Inspection

The Site was inspected on May 29, 2003. The inspection evaluated the barrier system currently in place for the repository and the undeveloped area of the Site. The barrier system appeared to be in very good condition. It appeared to be maintained in accordance with the SSOD and applicable plans and no significant problems were encountered. Access controls and signs were in place at areas of the Site that have not been completed such as the future location of the Medical Center. The fence was in good condition.

ARARs Review

As part of the five-year review, State and Federal Applicable and Relevant and Appropriate Requirements (ARARs) were reviewed. The primary purpose of this review was to determine if any newly promulgated or modified requirements of federal and state environmental laws have

significantly changed the protectiveness of the remedies implemented at the Site. The ARARs reviewed were those included in the 1998 ROD.

Overall, the review did not indicate any changes to regulations that would affect the remedy nor its protectiveness. The MCL for arsenic was changed from .05 mg/L to .01 mg/L in January of 2001. However, the effectiveness and protectiveness of the remedy were not affected because performance standards at Site boundaries are still being met and the appropriate institutional controls on the Site are still in place. The ACL for arsenic was not affected because it was based on the Creek's beneficial use which is agricultural. EPA and UDEQ will continue to monitor the Site and any significant changes or modifications in ARARs will be reported in the next five-year review.

VIII. Data Review for Operation & Maintenance

O&M activities apply only to the on-facility area (i.e. Category II, III and IV materials). O&M is not required for the off-facility area. O&M does not apply to Category I material because the material was removed from the Site.

Category III and IV materials will be addressed with IHC's construction of the Inter-mountain Medical Center. The materials will be covered with grading fill and overlying barriers. In accordance with the SSOD, a Barrier Monitoring and Management Plan will be required for the medical center.

Category II material was excavated and placed in the repository system. Generally, current O&M activities include monitoring of the repository for settlement, monitoring/maintenance of the repository barriers (i.e. new buildings, roads, sidewalks, parking lots) and drainage system. O&M requirements for the repository system are as follows:

- Monitoring of Repository System for Settlement
- Inspection and Maintenance of Roadways
- Inspection and Maintenance of UTAFRE Barrier
- Inspection and Maintenance of SWRE (Phase 2)
- Inspection and Maintenance of PURR & SWRE (Phase 2) Embankments
- Inspection and Maintenance of the Storm Water Drainage System
- Maintenance of Repository Liner System

Settlement Monitoring of Repository System. Review of survey data from settlement monuments and markers indicate minimal settlement and stable geo-technical conditions for the repository system. The data, from approximately 1.5 to 3 years of surveying, indicate less than 0.6 inches of settlement or composite movement. This is well below the expected long-term settlement or composite movement of 2.5 - 3.0 inches.

O&M Activities Requiring Inspection and Maintenance. Other than maintaining the

repository liner system, Murray City is required to implement the remaining O&M activities either directly or indirectly. A review of records and reports indicates that the O&M activities are being carried out in accordance with the Interim O&M Plan, SSOD, Pavement Management Plan and applicable Barrier Monitoring and Maintenance Plans. As of yet, no significant problems have been encountered during inspections of the barriers, embankments and drainage system.

Maintenance of Repository Liner System. A breach of the repository liner system has not occurred and, therefore, maintenance has not been required.

IX. Data Review for Groundwater Monitoring for Repository

In order to meet the substantive requirements of federal and state regulations relating to hazardous waste disposal facilities, three kinds of groundwater monitoring programs were established to monitor the effectiveness and protectiveness of the repository system. They are baseline monitoring, detection monitoring and compliance monitoring of the shallow aquifer. The monitoring is intended to detect early releases from the repository and demonstrate compliance with performance standards.

Four sets of paired wells and one compliance well are used during monitoring of the repository in the shallow aquifer. The four pair of wells were installed immediately following construction of the repository system. The up-gradient wells are MW-1U, -2U, -3U and -4D and the down-gradient wells are MW-1D, -2D, -3D and -4D. The compliance well, down-gradient of the repository system and south of the Creek, is MW-5D. See Figure 3 for details.

Baseline Monitoring for Repository

Baseline monitoring was initially required to establish groundwater conditions prior to any known releases from the repository system. Concentration levels for the two indicator parameters and other water quality parameters were measured prior to long-term containment of Category II material in the repository system. The baseline data has provided the basis for comparison to future monitoring results from the ongoing detection monitoring program and identification of changes in water quality that may be attributed to releases from the repository.

Evaluation Process for Baseline Monitoring Data. Figure 7 demonstrates the agreed-upon data evaluation process used for baseline monitoring. Data from a minimum of ten consecutive months will be acquired during baseline monitoring. Summary statistics will then be computed using methods appropriate to the data distributions. Prediction limits for the two indicator parameters will be computed for each pair of up-gradient and down-gradient wells. The appropriate method for computing the prediction limit will depend on whether the up-gradient and down-gradient data are distinct from each other and on the distribution of the data used.

For the two indicator parameters, data from the paired wells will be compared using a non-parametric method to test the hypothesis that the baseline conditions at the up-gradient and down-

gradient wells are the same. A two-sided Mann-Whitney rank-sum test will be used to test this hypothesis at the 95 percent confidence level. If the test results for an individual indicator parameter demonstrate that the up-gradient and down-gradient data are not significantly different, at the 95 percent confidence level, all of the baseline data for the well pair will be combined to compute a prediction limit for that indicator parameter. If test results demonstrate that the up-gradient and down-gradient data are different, then the prediction limit will be computed using only data collected from the down-gradient well.

Prediction limits for each indicator parameter at each well will serve as the initial basis for comparison of background data during the detection monitoring program. The appropriate computation methods, based on the results of a distribution test and the detection frequency, will be used to obtain the prediction limit for each indicator parameter at each down-gradient well.

Analysis of Baseline Monitoring Data. The paired wells and compliance well were sampled for ten consecutive months after the wells were installed (November 2000 to August 2001). Data results from the baseline monitoring for arsenic and sulfate are shown in Table 1 and Table 2, respectively. In accordance with the agreed-upon data evaluation process in the Remedial Design Report for Groundwater and Surface Water Monitoring (RDRGSWM), prediction limits for the two indicator parameters were computed for each pair of up-gradient and down-gradient wells using the baseline data. The prediction limits for the paired wells will serve as the initial basis for comparison to future monitoring results from the ongoing detection monitoring program.

Data results for Compliance Well MW-5D are shown in Table 3. Along with normally required parameters, MW-5D was sampled for metals/metalloids with state groundwater standards. Data from baseline monitoring will incorporate data from the ongoing detection monitoring program to evaluate compliance with performance standards using temporal trends.

Detection Monitoring for Repository

Following baseline monitoring, repository wells were monitored on a quarterly basis to identify statistically significant changes in groundwater quality within the shallow aquifer that may be attributed to releases from the repository. Indicator parameters are arsenic and sulfate. Temporal variations in arsenic and sulfate concentrations in four paired wells (up-gradient and down-gradient of the repository) are to be compared to identify statistically significant changes in water quality in the immediate vicinity of the repository. For Compliance Well MW-5D, arsenic and sulfate temporal trends are to be used to evaluate compliance with performance standards.

Evaluation Process for Detection Monitoring Data. Figure 8 demonstrates the agreed-upon data evaluation process used for the ongoing detection monitoring program. Changes in water quality relative to baseline conditions will be identified through either comparison to the prediction limits or time-series analyses, depending on whether temporal trends in indicator parameter concentrations are evident. For each well and each indicator parameter, time-series data will be plotted and linear regression analysis performed. The Mann-Kendall test for trend will be used to identify significant time-series trends of either increasing or decreasing

concentration with time. The Mann-Kendall test for trend is a non-parametric test that can identify trends at a specified confidence level. The test should be performed on data for all paired wells at the 90 percent confidence level.

Depending on whether significant temporal trends are observed for an indicator parameter in a down-gradient well, up-gradient to down-gradient comparisons will be performed using one of two methods:

- If the result of the Mann-Kendall test shows no temporal trend at the 90% confidence level, then the mean concentration of monitoring data from the down-gradient well for the four most recent quarters will be compared to the baseline prediction limit for that well; or

- If the result of the Mann-Kendall test shows a trend of increasing or decreasing concentration with time at the 90% confidence level, then a Chi-square test for homogeneity of trends will be applied.

If the baseline prediction limit is not exceeded by the mean concentration, then the most recent measurements are consistent with baseline measurements and there is no evidence for a release from the repository. In this case, the most recent data will be added to the baseline data sets and used to recalculate the prediction limit for future comparison.

If a temporal trend is identified for an indicator parameter in a down-gradient well, the Chi-square test for homogeneity of trend direction can be used to identify common trends among multiple wells at a known confidence level. This method uses results from the Mann-Kendall trend tests to objectively identify similar temporal trends. When the trends at the up-gradient and down-gradient wells are the same, temporal variations at the down-gradient well are not indicative of a release from the repository. In this case, the most recent data will be added to the baseline data sets and used for future comparisons. Reevaluation of the baseline data will be required on an annual basis.

If a baseline prediction limit is exceeded or if temporal trends are divergent, then the most recent measurements are not consistent with baseline measurements and indicate a change in water quality that may be attributable to a release from the repository. In this case, the collection of additional data may be required to evaluate whether the increasing concentrations of one or more of the indicator parameters are the result of a release from the repository or from other variables at the Site. Additional efforts may include a more detailed review of data from other groundwater monitoring programs related to the Site, further evaluation of O&M information related to the repository or the use of leak-detection equipment to confirm a leak(s) from the repository, if any. If a cause other than a release from the repository cannot be identified, the necessary corrective actions will be taken by Asarco.

Analysis of Detection Monitoring Data - Paired Wells. Sampling data, from the first four quarters after completion of the baseline monitoring program, were evaluated in accordance with the agreed-upon data evaluation process. For arsenic, Table 4 shows that the Mann-Kendall test

for upward trend is negative at the 90% confidence level for all wells, except down-gradient well MW-2D. Table 4 also shows that for all wells, except MW-2D, the mean concentration does not exceed the baseline prediction limit. Therefore, data from all wells, except MW-2D, are consistent with baseline measurements and there is no evidence of a release from the repository.

Following proper data evaluation procedure, paired wells, MW-2U and MW–2D, were then tested for homogeneity using the Chi-square test and were found not to be trending in the same direction as shown in Table 6. These results would suggest a statistically significant change in groundwater quality within the shallow aquifer attributable to a release from the repository.

However, additional data was used to verify these results in accordance with the agreed-upon data evaluation process. When arsenic data for the next two quarters are added to the data set, the outcome of the data evaluation for MW-2D is different as shown in Table 7. The Mann-Kendall test for upward trend is now negative at the 90% confidence level and the mean arsenic concentration does not exceed the baseline prediction limit for arsenic. Therefore, the results for MW-2D are now consistent with baseline measurements and there is no evidence of a release from the repository.

For sulfate, the upward trend test is negative at the 90% confidence level for all wells except up-gradient wells MW-1U and MW-4U. These results suggest that the contamination is from residual smelter material not a release from the repository. Both wells are immediately down-gradient of areas where Category II material was removed. In addition, if there had been a release from the repository, the down-gradient wells would have shown an upward trend as well.

The above evaluation of paired-well data illustrates an important point. The correlation between elevated arsenic concentrations in groundwater and areas of residual smelter source materials must be considered when evaluating detection monitoring data. The repository system cuts through several discrete areas where significant groundwater contamination existed, prior to the installation of the repository, due to Category I & II materials. Because of the high attenuation characteristics of arsenic and the low permeability of the aquifer system, arsenic concentrations in groundwater have been measured at relatively high concentrations in groundwater immediately beneath previously known contaminated areas, but at very low concentrations just down-gradient of those areas. This complicates the evaluation of data from detection monitoring. Concentrations of indicator chemicals in down-gradient wells could well be the result of highly variable preexisting conditions and not necessarily releases from the repository.

Analysis of Detection Monitoring Data - Compliance Well MW-5D. Data results for Compliance Well MW-5D are shown in Table 8. Data from the ongoing detection monitoring program was added to the data from baseline monitoring to evaluate compliance with performance standards. Data was plotted versus time for the two indicator parameters (arsenic and sulfate) and metals with concentrations above state groundwater standards (cadmium and lead) as shown in Figures 9, 10, 11 and 12.

For MW-5D, arsenic is well below the ACL of 5 mg/L. Sulfate does not have an ACL nor an

MCL and exhibits moderate variability. Both cadmium and lead were consistently above state groundwater standards. Given the baseline monitoring data for MW-5D, the contamination is likely due to preexisting conditions. According to the RDRGSWM, ACLs should be considered for cadmium and lead for the shallow aquifer within Site boundaries.

Compliance Monitoring for Repository

Compliance monitoring is required only if the data from detection monitoring shows a statistically significant increase in one or both of the indicator parameters (arsenic and sulfate). Compliance monitoring includes quarterly sampling of Compliance Well MW-5D and adding metals/metalloids with state groundwater standards to the analytical parameter list. Detection monitoring did not show a statistically significant increase in one or both of the indicator parameters from November 2001 to February 2003 and, therefore, compliance monitoring was not required.

X. Data Review for Groundwater Monitoring of the Shallow Aquifer

Groundwater Flow North of Creek

Water levels are measured on a quarterly basis at three piezometers just north of Little Cottonwood Creek (Creek). Along with water level measurements of the Creek and wells just south side of the Creek, the data is used to evaluate groundwater flow north of the Creek. The piezometers are PZ-1, -2 and -3. See Figure 4.

Water level measurements from the piezometers have been combined with other measurements from the Site to develop potentiometric surface maps on a quarterly basis. All previous maps for the shallow aquifer confirm that groundwater from the on-facility area discharges into the Creek and does not flow north of the Creek. Figure 13 is an example of a potentiometric map using data from May of 2002.

Groundwater Quality at Creek

Three wells, just south of the Creek, are monitored on a quarterly basis and monitor the northern boundary of the Site. The data is used to compare arsenic concentrations in groundwater discharging into the Creek to the Alternate Concentration Limit (ACL) of 5 mg/L. EPA established the ACL to protect the Creek at its beneficial use which is agricultural. The three wells are SPM-3, -4 and –5. See Figure 4.

The RDRGSWM requires a minimum of three years of sampling data to adequately calculate a statistical concentration value for each well and compare the value to the ACL for arsenic. Only two years and one quarter of data are available and, therefore, compliance with the ACL cannot be demonstrated at this time. Using available data and for information purposes only, statistical concentration values (90/95 UTL) for arsenic were calculated as shown in Table 9. 90/95 Upper Tolerance Limit (UTL) represents the 90th percentile value at the 95 percent confidence level.

The values were .07 mg/L for SMP-3, .11 mg/L for SMP-4 and .38 mg/L for SMP-5. The values were well below the ACL of 5 mg/L. In addition, no appreciable increases in arsenic were apparent in any of the wells.

Groundwater Quality at Western Boundary

Groundwater in the shallow aquifer flows in a north-northwesterly direction. The northern boundary of the Site is being monitored by SPM-3, SPM-4 and SPM–5 as previously discussed. The western boundary is being monitored by SPM-1 and SPM-2. The two wells are immediately outside the western boundary of the on-facility area and are being monitored on a quarterly basis to compare arsenic concentrations in shallow groundwater leaving the Site to the MCL of 0.05 mg/L. See Figure 4.

The RDRGSWM requires a minimum of three years of sampling data to adequately calculate a statistical concentration value for each well and compare the value to the MCL for arsenic. Only two years and one quarter of data are available for SPM-1 and only one year and three quarters for SPM-2. Therefore, compliance with the MCL cannot be demonstrated at this time. Using available data and for information purposes only, statistical concentration values (90/95 UTL) for arsenic were calculated as shown in Table 9. The values were .009 mg/L for SMP-1 and .007 mg/L for SMP-2. The values were below the current MCL of .01 mg/L. In addition, no appreciable increases in arsenic were apparent in the two wells.

XI. Data Review for Groundwater Monitoring of the Intermediate Aquifer

Four intermediate aquifer wells within the on-facility area are monitored on a quarterly basis to compare arsenic concentrations to the MCL. The wells are IPM-1, -2, -3 and –4. See Figure 5.

The RDRGSWM requires a minimum of three years of sampling data to adequately calculate a statistical concentration value and compare the value to the MCL for arsenic. After 3 years, the sampling arsenic data for the four intermediate wells are to be pooled to calculate a mean concentration and a statistical concentration value. Only two years and one quarter of data are available for the four intermediate wells. Therefore, compliance with the MCL cannot be demonstrated at this time. Using available data and after pooling the data from the four wells, a mean concentration and a statistical concentration value (90/95 UTL) for arsenic were calculated as shown in Table 10. The mean concentration was .0083 mg/L and the statistical value was .029 mg/L - both are below the state groundwater standard for arsenic of .05 mg/L and the statistical value is slightly higher than the current MCL of .01 mg/L. In addition, no appreciable increases in arsenic were apparent in any of the wells.

XII. Data Review for Surface Water Monitoring

The Creek is monitored on a semi-annual basis at three locations. Samples are taken during low-

flow and high-flow conditions at the Creek. The three locations are SW-13 (upstream of the Site boundary), SW-15 (within the Site boundaries) and SW-5 (immediately downstream of the Site boundary). Arsenic data from SW-5 are compared to Utah's Ambient Water Quality Criteria (AWQC) for aquatic life (0.19 mg/L trivalent arsenic as a 4-day average, 0.36 mg/L trivalent arsenic as a 1-hour average) and Agricultural Use Standard (0.1 mg/L). See Figure 6.

Thus far, the Creek has been sampled five times beginning January of 2001. Dissolved trivalent arsenic in SW-5 has been below the AWQC for aquatic life for all events as shown in Table 11. Dissolved arsenic in SW-5 has been below the Agricultural Use Standard for all events, except for the first one. The dissolved arsenic concentration for that low-flow event in January 2001 was 0.11 mg/L, slightly above the standard of .10 mg/L.

XIII. Data Review for Monitored Natural Attenuation

Four wells within the on-facility area are currently being monitored on a semi-annual basis to evaluate the performance of natural attenuation. With time, the data will be used to describe changes in the distribution and concentration of arsenic within the shallow aquifer. The four wells are MW-1D, -2D, -3D and 104. Three additional wells to monitor the effects of monitored natural attenuation were required to be installed in the area now occupied by Costco. Installation of the wells was postponed due to the construction of Costco. Costco was completed in January of this year and installation of the three wells is now required. The designations of the three wells will be M-10, -11 and -12. See Figure 4 for details.

The RDRGSWM requires a minimum of three years of monitoring to adequately plot time-series data for arsenic and to perform linear regression analysis for each well. The Mann-Kendall test for trend will be used to identify significant time-series trends of either increasing or decreasing concentration with time. The Mann-Kendall test for trend is a non-parametric test that can identify trends at a specified confidence level. Using available arsenic data and for information purposes only, the Mann-Kendall test at the 90% confidence level was performed on each of the wells as shown in Table 10. The tests do not show statistically significant trends for any of the wells. This indicates that source removal/source control and natural processes have not affected natural attenuation as of yet.

XIV. Assessment

The following conclusions support the determination that the remedy at the Site is expected to be protective of human health and the environment upon completion.

Question A: Is the remedy functioning as intended by the decision documents?

- ***HASP/Contingency Plan:*** Currently, a Health & Safety and Contingency Plans are not

necessary for the Site. They will be necessary during construction of the Inter-mountain Medical Center which, as a whole, will serve as a barrier to Category III and IV materials.

- ***Implementation of Institutional Controls and Other Measures:*** Access controls and signs are in place at areas of the Site that have not been completed such as the future location of the Medical Center. The fence is in good condition.

  Institutional controls are effectively in place throughout the Site. In accordance with the ROD, Murray City created the Smelter Site Overlay District (SSOD) with the passage of Ordinance 98-07 on April 14, 1998. The SSOD established the necessary public and private ICs to protect human health and environment from the remaining contamination at the Site and to protect the integrity of current and future barriers/caps. Specifically, the SSOD prohibits the construction of new wells or use of existing wells for any purpose, includes zoning to prevent residential and contact intensive industrial uses within the former smelter operational areas and requires maintenance of the barriers/caps and controls on handling of excavated subsurface material. All current and future redevelopment activities in the on-facility area must conform to SSOD requirements. Also, under Section II, Number 2, of the *Salt Lake Valley Interim Ground-water Management Plan,* well applications will not be granted in areas where a public water system is available. Nearby residents and businesses are all connected to the municipal water system.

  Remedial Action Performance: With the proper controls in place, the barrier system has been effective in protecting the integrity of the repository. Owners of property at the Site are required, by the SSOD, to develop and implement a Barrier Monitoring and Maintenance Plan for their respective properties. Due to this requirement, the barrier system is regularly inspected and well maintained by the various property owners including the Murray City. Groundwater monitoring has been conducted in accordance with all requirements. Currently, groundwater contaminant levels throughout the Site are consistent with expectations at the time of the ROD. At Site boundaries, contaminant levels in groundwater are below performance standards.

- ***O&M and Monitoring:*** O&M and Monitoring activities are being conducted in accordance with all appropriate plans, manuals and ordinances. Inspection and maintenance procedures are consistent with all requirements. Maintenance issues that have occurred with repository barriers have been handled properly to date.

- ***Opportunities for Optimization:*** Currently, there are no opportunities for optimization. After three years of groundwater data accumulation, the various groundwater programs will be evaluated for necessity and effectiveness.

- ***Early Indicators of Potential Remedy Failure:*** No early indicators of potential remedy failure were noted during the review.

Question B: Are the assumptions made at the time of the remedy selection still valid?

- ***Changes in Standards:*** No newly promulgated or modified ARARs that would change the protectiveness of the remedies implemented at the Site were found. The MCL for arsenic was changed from .05 mg/L to .01 mg/L in January of 2001. However, the effectiveness and protectiveness of the remedy were not affected because performance standards at Site boundaries are still being met and the appropriate institutional controls on the Site are still in place. The ACL for arsenic was not affected because it was based on the Creek's beneficial use which is agricultural.

- ***Changes in Exposure Pathways:*** No changes in site conditions that affect exposure pathways were identified as part of the five-year review. First, there are no planned changes in land use. Second, no new contaminants, sources, or routes of exposure were identified as part of this five-year review. Finally, there is no indication that hydrologic/hydrogeologic conditions are not adequately characterized. Present contaminant levels in groundwater are consistent with expectations at the time of the ROD.

- ***Changes in Toxicity and Other Contaminant Characteristics:*** Changes in toxicity and other factors for contaminants of concern, since the time of the ROD, do not call into question the protectiveness of the remedy.

- ***Changes in Risk Assessment Methodologies:*** Changes in risk assessment methodologies, since the time of the ROD, do not call into question the protectiveness of the remedy.

Question C: Has any other information come to light that could call into question the protectiveness of the remedy?

No additional information has been identified that would call into question the protectiveness of the remedy.

XV. Issues

Issues that do not immediately impact the protectiveness of the remedy were identified during the five-year review. The six issues were as follows:

1. **Evaluation Process for Repository.** Analysis of data related to the repository was found to be difficult due to the impact of preexisting conditions at the Site and data variability. The current approach in evaluating the repository system needs to be reevaluated.

2. **Change in MCL for Arsenic.** The MCL for arsenic was changed from .05 mg/L to .01 mg/L in January of 2001. The modified MCL will need to be used in data evaluation.

3. **Evaluation of ACLs for Cadmium and Lead.** During baseline and detection monitoring, cadmium and lead levels were consistently found to be above MCLs in

Compliance Well MW-5D. The contamination is likely due to preexisting conditions. MW-5D is down-gradient of the repository system and south of the Creek. Alternate Concentration Limits (ACLs) for cadmium and lead should be evaluated.

4. **Reporting Requirements.** Comprehensive and complete information on the status of the remedy was not readily available at the start of this five-year review. Needed information was subsequently provided by Asarco and Murray City in a timely and acceptable manner.

5. **Addition of Three Wells for Measurement of Natural Attenuation.** Three additional wells to monitor the effects of monitored natural attenuation were required to be installed in the area now occupied by Costco. Installation of the wells was postponed due to the construction of Costco. Costco was completed in January of this year and installation of the three wells is now required.

XVI. Recommendations and Follow-up Actions

With EPA oversight, the corresponding recommendations/follow-up actions are as follows:

1. **Evaluation Process for Repository.** The reevaluation should include rigorous review of the statistical approach, frequency of groundwater sampling related to the repository and choice of indicator parameters. After three full years of data accumulation, the reevaluation should be initiated. Possible outcomes of the reevaluation could be confirmation of the efficiency and effectiveness of the current approach, modifications to the current approach or a completely different approach.

2. **Change in MCL for Arsenic.** Where applicable, the modified MCL will be the performance standard and will need to be used in data evaluation from this point forward.

3. **Evaluation of ACLs for Cadmium and Lead.** Given sampling results and according to the RDRGSWM, ACLs should be evaluated for cadmium and lead for the shallow aquifer within Site boundaries as was done for arsenic. The evaluation process should begin by sampling all wells for all metals/metalloids with state groundwater standards to verify that elevated cadmium/lead levels are located only in the immediate area of MW-5D. Further sampling of wells for all metals/metalloids with state groundwater standards will be determined by review of the initial set of sampling results.

4. **Reporting Requirements.** To adequately and regularly measure the effectiveness and protectiveness of the remedy, Asarco and Murray City should provide comprehensive and complete annual reports on their respective responsibilities to EPA and UDEQ on an annual basis. Annual reports will be due on December 31 of each year.

5. **Addition of Three Wells for Measurement of Natural Attenuation.** The three additional wells to monitor the effects of monitored natural attenuation should be installed

in the Costco area by the end of this year.

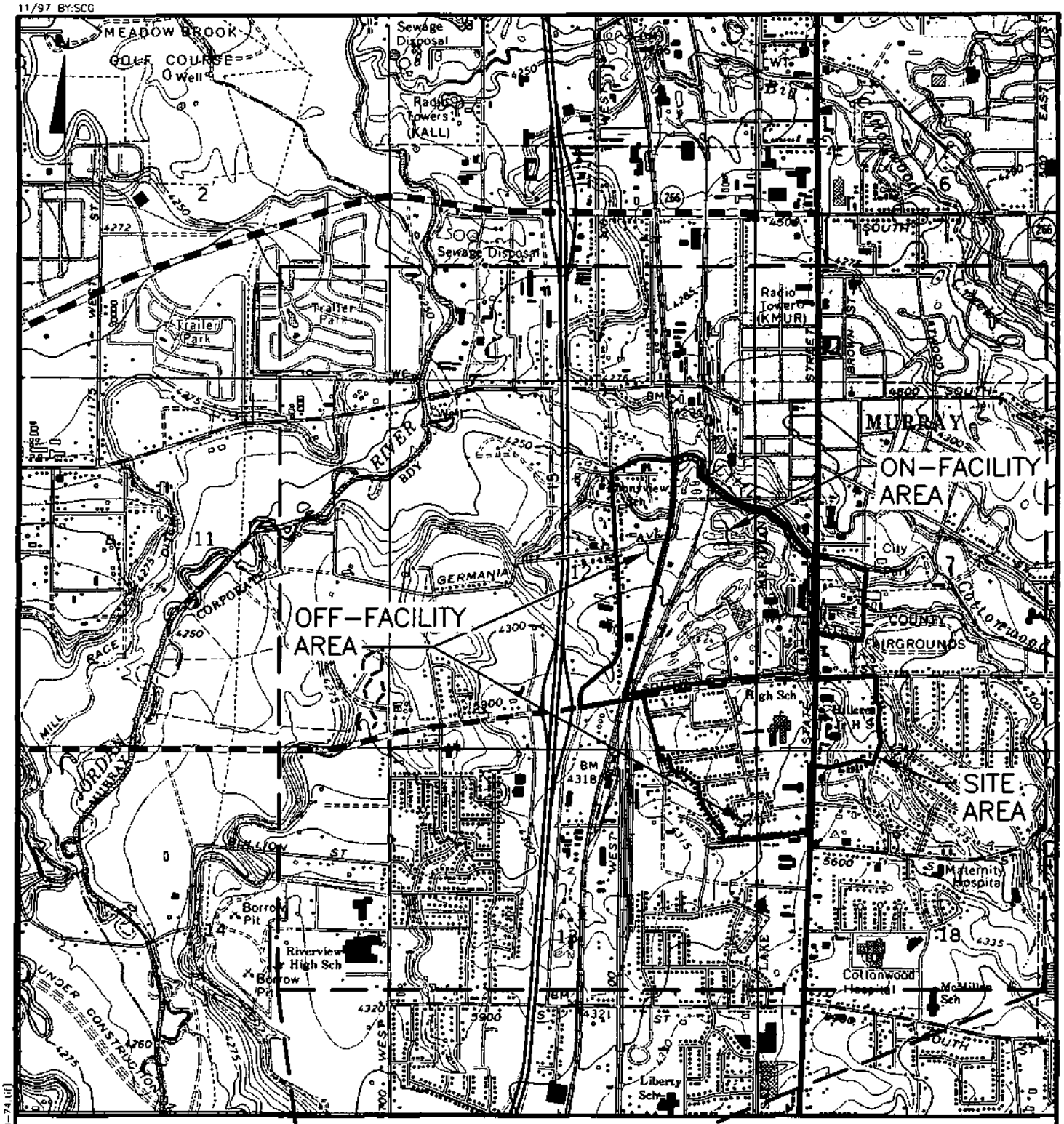
XVII. Protectiveness Statements

The remedy at the Former Murray Smelter Superfund Site is expected to be protective of human health and the environment, and immediate threats have been addressed. The repository and barrier systems are being monitored and maintained as designed. Stringent institutional controls for the Site are in place with the establishment and enforcement of the Smelter Site Overlay District. Access controls and signs are effectively in place at areas of the Site that have not been completed such as the future location of the Inter-mountain Medical Center. Contaminant levels along Site boundaries are below performance standards. Contaminant levels in shallow groundwater within Site boundaries are consistent with expectations at the time of the ROD. In addition, residents and businesses in the area are connected to the municipal water system.

XVIII.Next Review

This review was required by statute. The next review will be conducted within five years of the completion of this five-year review report. The completion date is the date of the signature shown on the signature cover attached to the front of the report.

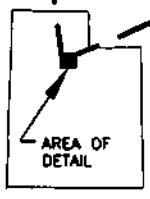
11/97 BY:SCG



FROM USGS, 7-1/2 MIN. QUAD MAP, SLC SO., 1975.

SCALE

2000 0 2000 FEET



UTAH

ASARCO Incorporated
FORMER MURRAY SMELTER SITE

FIGURE 1

SITE LOCATION MAP

PROJECT: 015324.3	DATE: AUGUST 2003
REV:	BY: SCG CHECKED: ACK

MFG, Inc.
consulting scientists and engineers

SCG 5324-341.dwg O:\5324\ 015324.3 8.5x11 1=40 8/19/03 11:40 am
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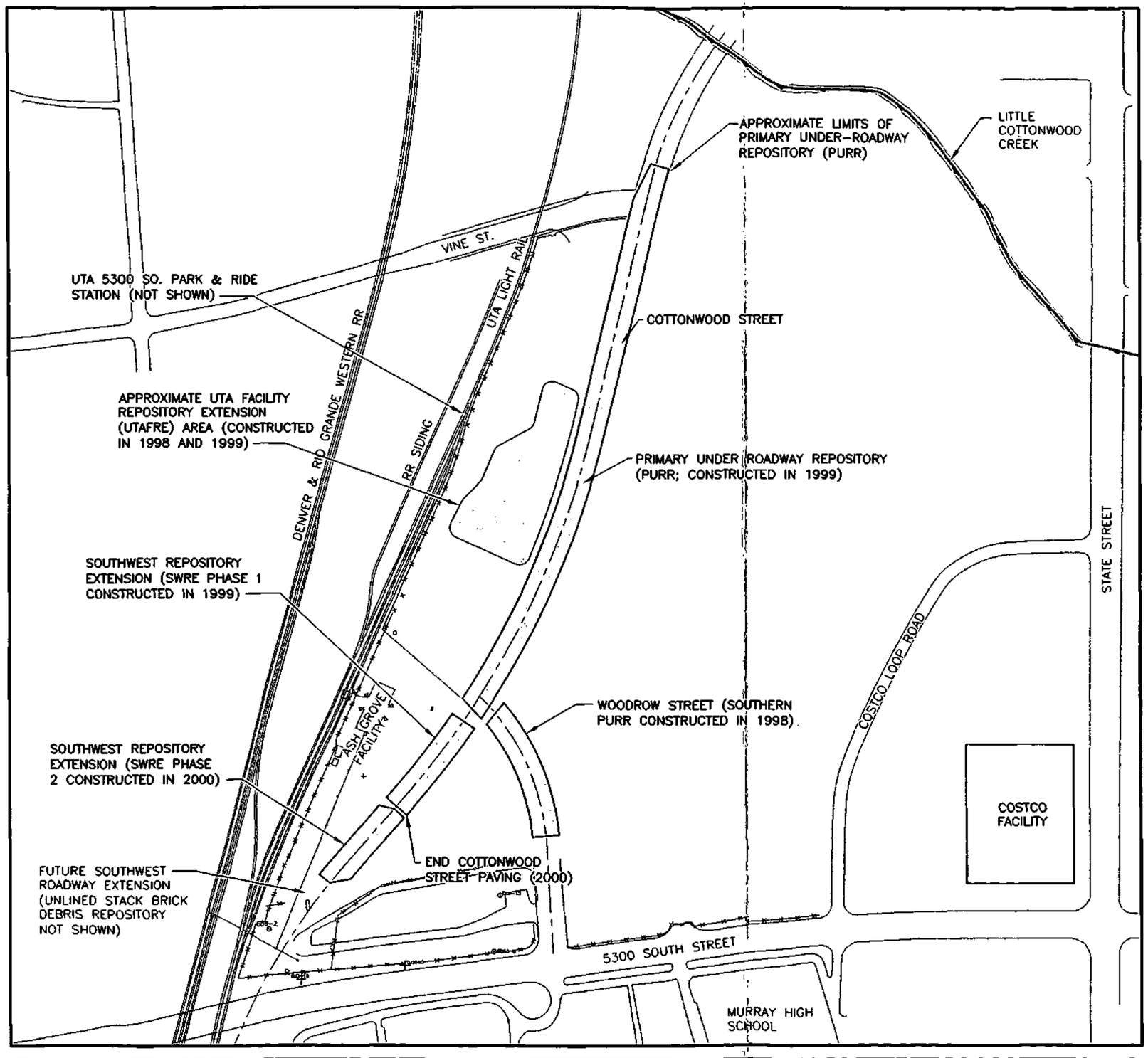

ASARCO Incorporated
FORMER MURRAY SMELTER SITE

FIGURE 2

REPOSITORY SYSTEM FOR CATERGORY II MATERIALS

PROJECT: 015324.3	DATE: AUGUST 2003
REV:	BY: SCG CHECKED: ACK

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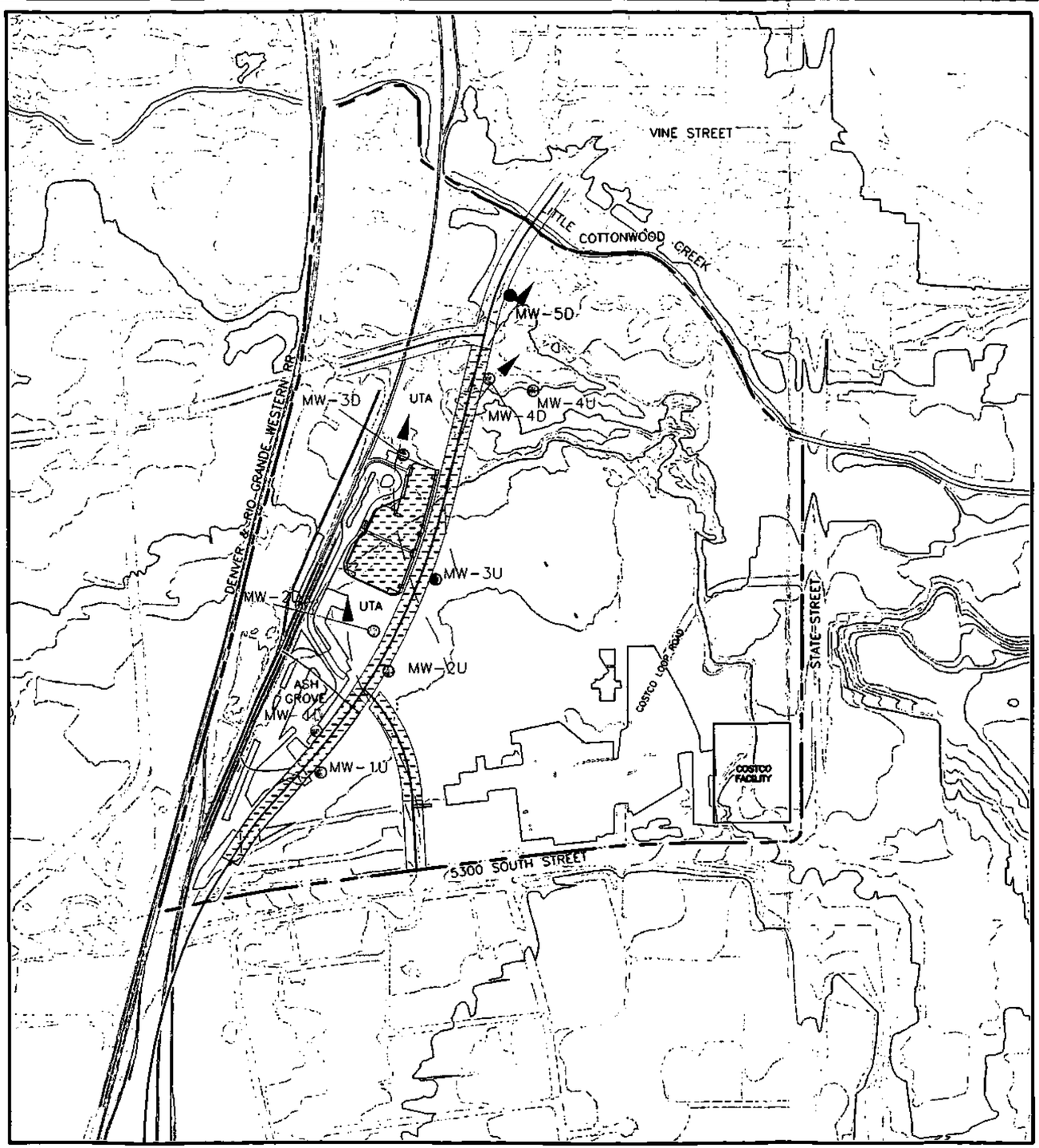
Color Map(s)

The following pages contain color that does not appear in the scanned images.

To view the actual images, please contact the Superfund Records Center at (303) 312-6473.

2/00 BY:RHF



LEGEND:

- UPGRADIENT AND DETECTION MONITORING WELL PAIRS
- POINT OF COMPLIANCE MONITORING WELL
- APPROXIMATE CATEGORY II MATERIAL REMOVAL AREAS
- INFERRED GROUNDWATER FLOW PATH (APPROXIMATE)
- ROADWAY EXTENSION AND ON-FACILITY REPOSITORY, SYSTEM

N

SCALE

500 0 500 FEET

ASARCO Incorporated
FORMER MURRAY SMELTER SITE

FIGURE 3
SHALLOW GROUNDWATER MONITORING WELLS FOR REPOSITORY SYSTEM

PROJECT: 015324.3	DATE: AUGUST 2003
REV:	BY: SCG CHECKED: ACK

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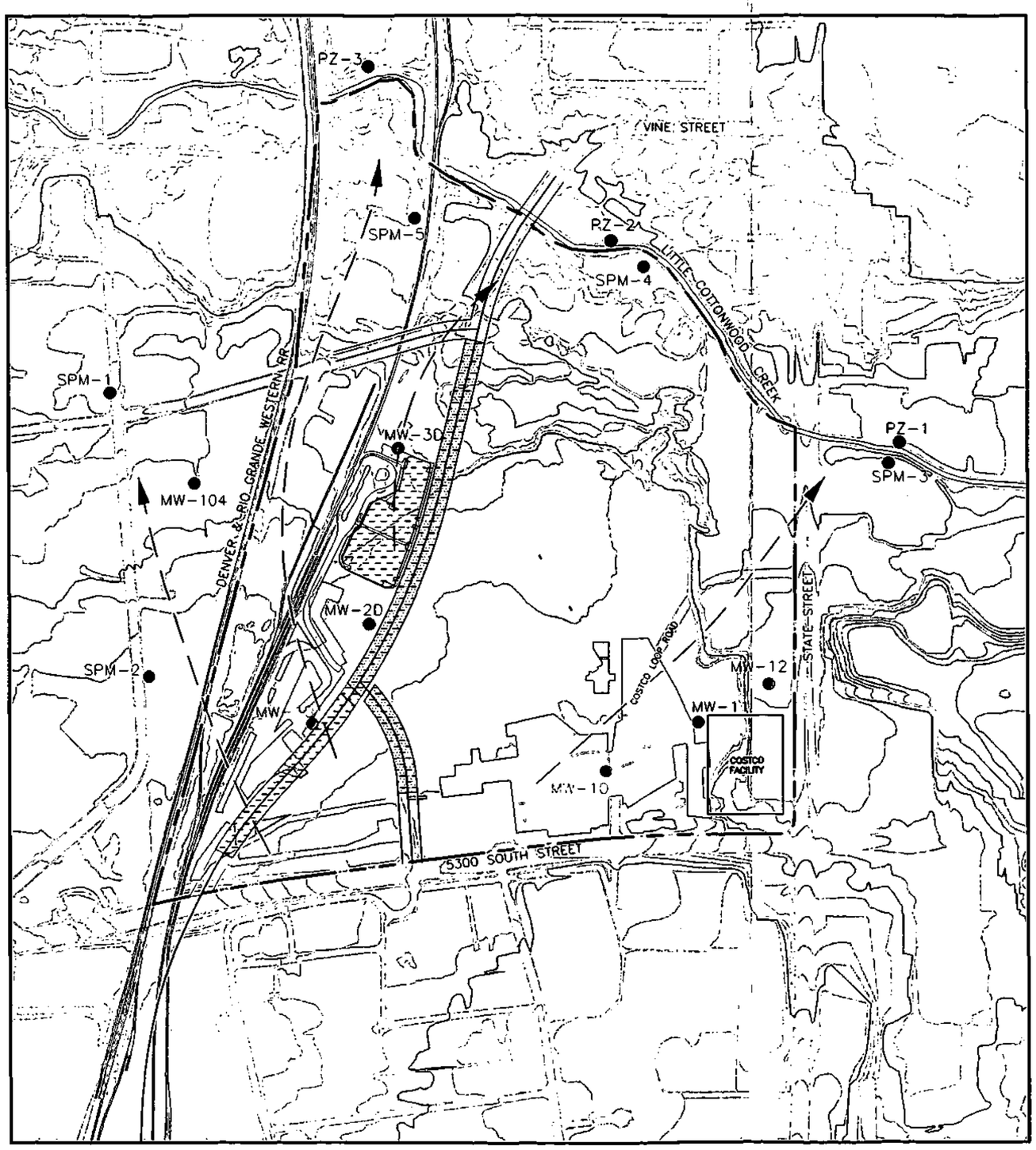
images: none

Plot time: 4:34 pm
Plot date: 9/2/03

06/03 BY:SCG



LEGEND:

- PZ-1 — NORTH-BOUNDARY PIEZOMETER
- SPM-1 — PERFORMANCE MONITORING FOR MCL COMPLIANCE
- SPM-4 — PERFORMANCE MONITORING FOR ACL COMPLIANCE
- MW-14 — SHALLOW AQUIFER WELL FOR MONITORING NATURAL ATTENUATION
- APPROXIMATE CATEGORY II MATERIAL REMOVAL/EXCAVATION AREAS
- ON-FACILITY BOUNDARY
- INFERRED GROUNDWATER FLOW PATH
- ROADWAY EXTENSION AND ON-FACILITY REPOSITORY, SYSTEM

NOTE:

1. WELLS MW-10, -11 AND -12 ARE PROPOSED LOCATIONS.

N

SCALE

500 0 500 FEET

ASARCO Incorporated
FORMER MURRAY SMELTER SITE

FIGURE 4

PERFORMANCE MONITORING WELLS FOR SHALLOW AQUIFER

PROJECT: 015324.3	DATE: AUGUST 2003
REV:	BY: SCG CHECKED: ACK

MFG, Inc.
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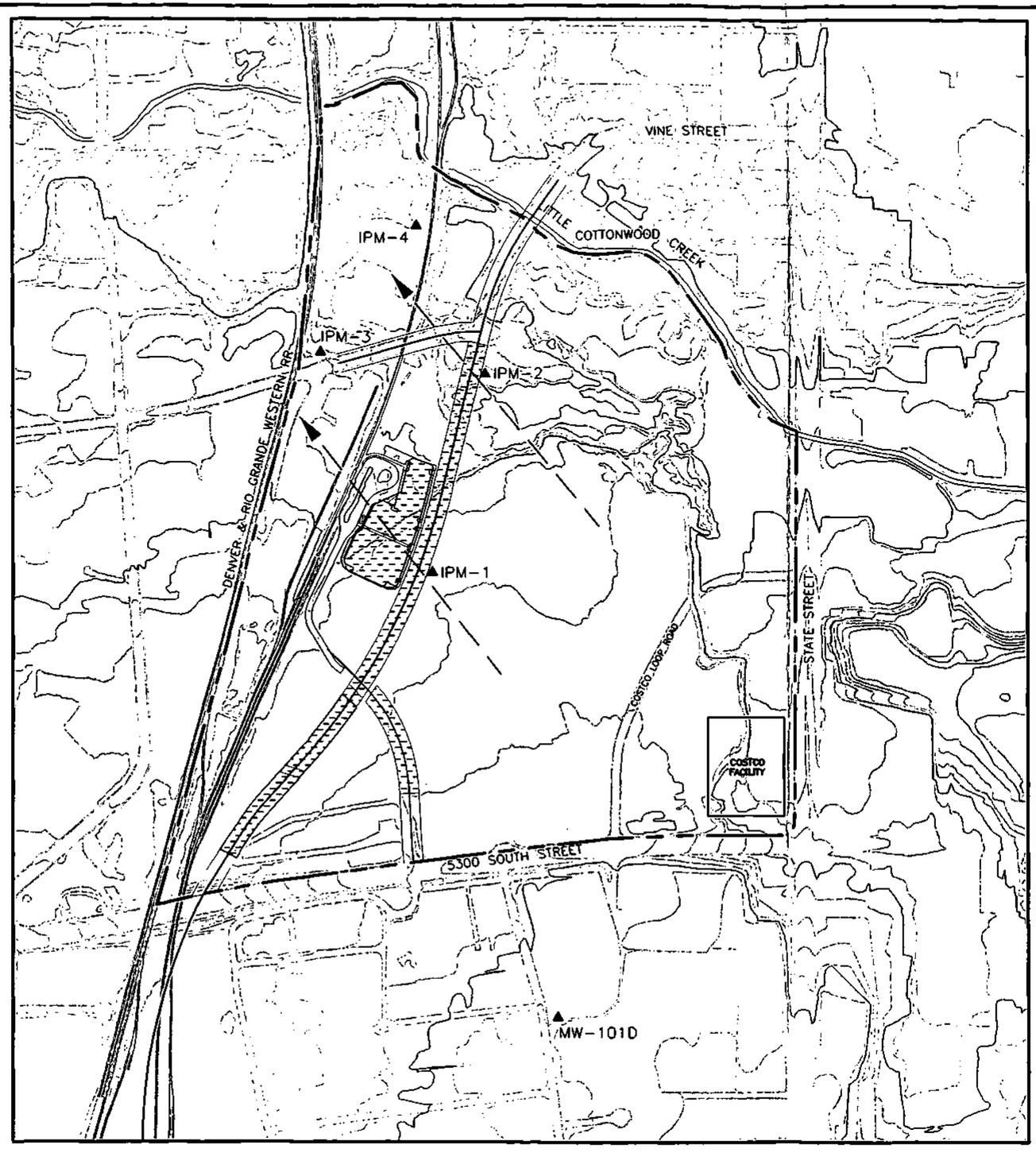
Plot date 9/3/03
By: SCG

11/97 BY:PRM



LEGEND:

IPM-3 ▲ INTERMEDIATE AQUIFER MONITORING WELL LOCATION

BOUNDARY OF ON-FACILITY AREA

ROADWAY EXTENSION AND ON-FACILITY REPOSITORY, SYSTEM

INFERRED GROUNDWATER FLOW PATH

N

SCALE

500 0 500 FEET

ASARCO Incorporated
FORMER MURRAY SMELTER SITE

FIGURE 5

PERFORMANCE MONITORING WELLS FOR INTERMEDIATE AQUIFER

PROJECT: 015324.3	DATE: AUGUST 2003
REV:	BY: SCG CHECKED: ACK

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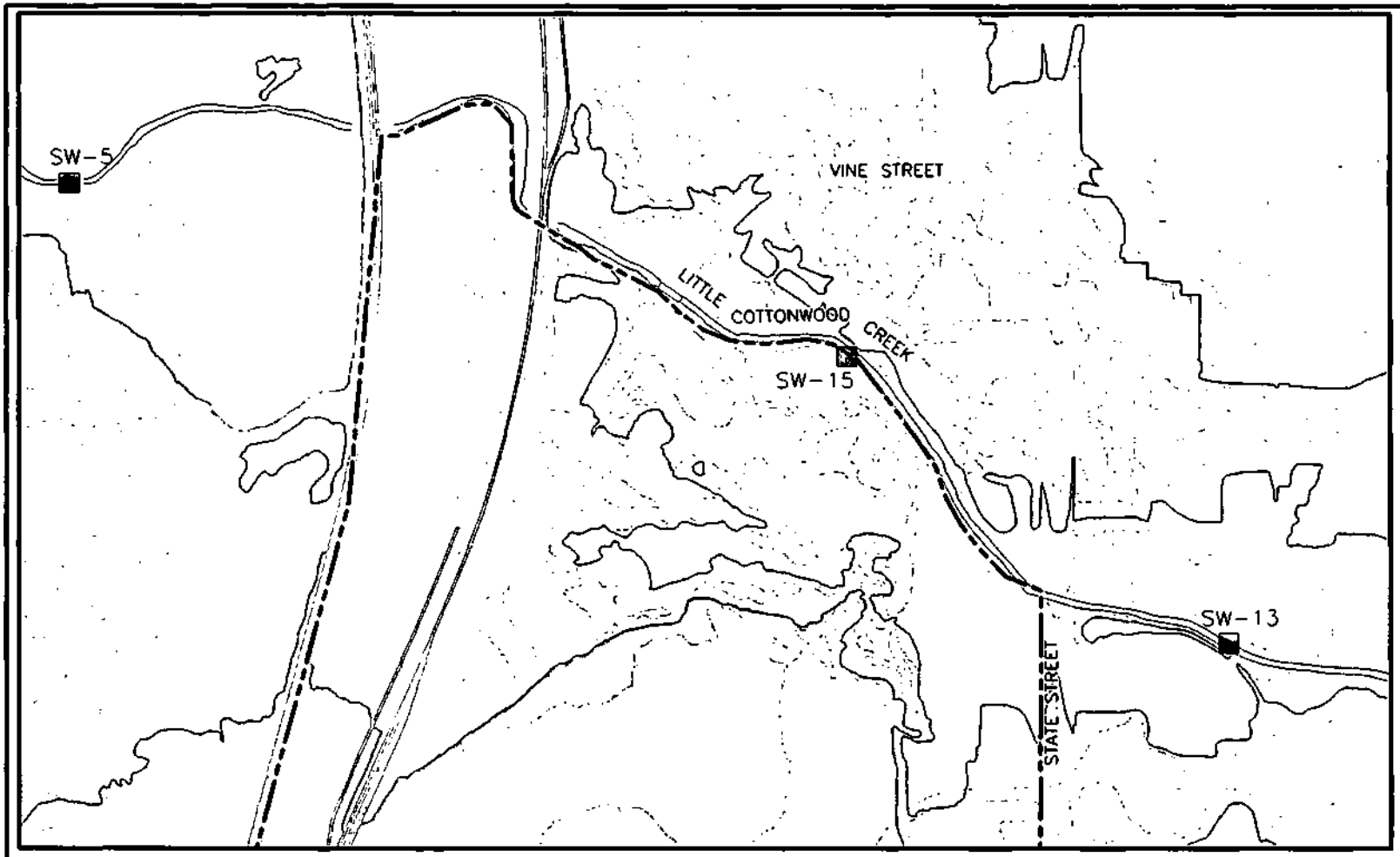

SCALE

500 0 500 FEET

LEGEND:

SURFACE WATER MONITORING LOCATION

BOUNDARY OF ON-FACILITY AREA

ASARCO Incorporated
FORMER MURRAY SMELTER SITE

FIGURE 6
SURFACE WATER MONITORING LOCATIONS FOR LITTLE COTTONWOOD CREEK

PROJECT: 015324.3	DATE: AUGUST 2003	
REV:	BY: SCG	CHECKED: ACK

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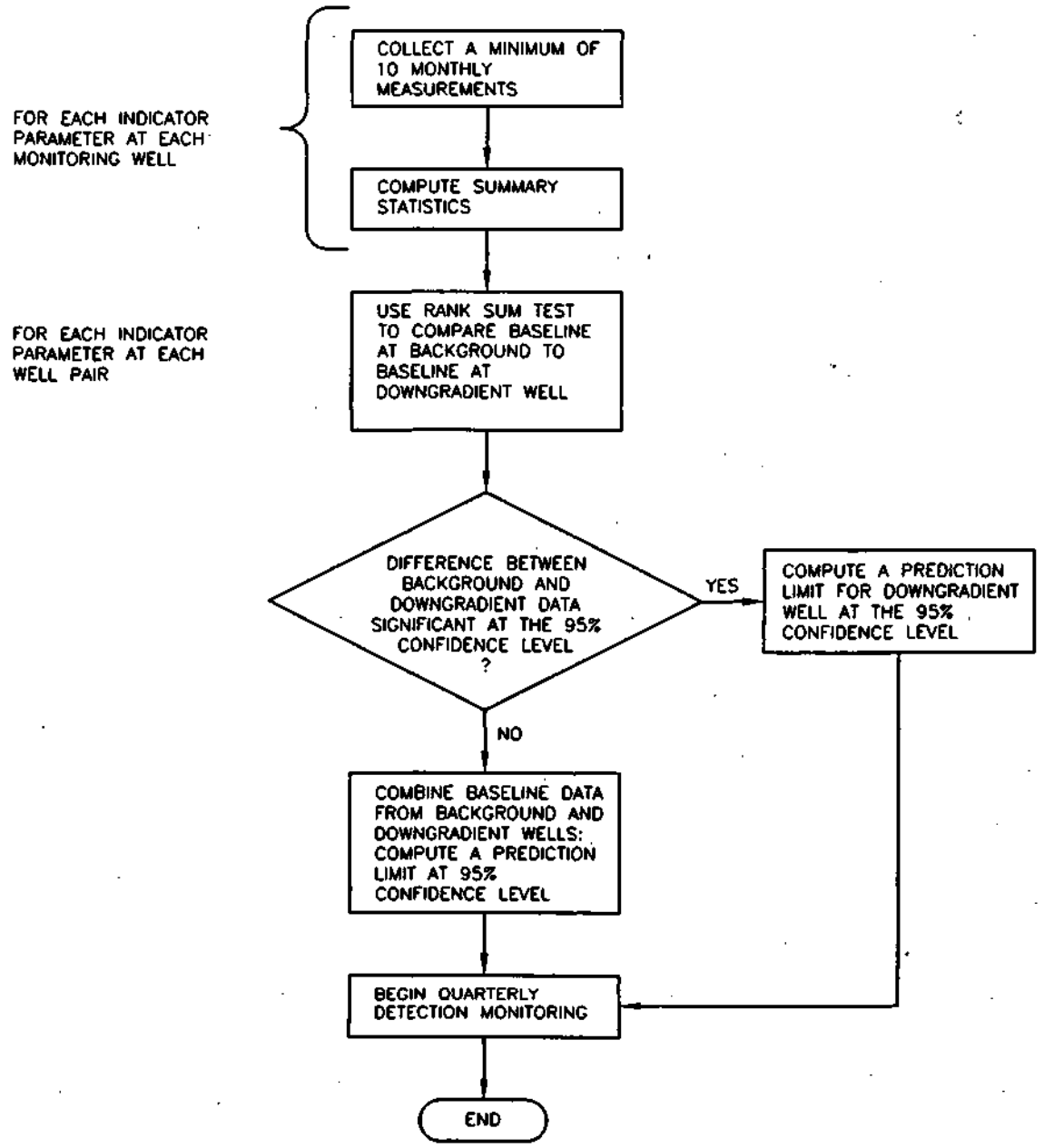

ASARCO Incorporated
FORMER MURRAY SMELTER SITE

FIGURE 7

DATA EVALUATION PROCESS FOR BASELINE MONITORING

PROJECT: 015324.3	DATE: AUGUST 2003	
REV:	BY: SCG	CHECKED: KJT

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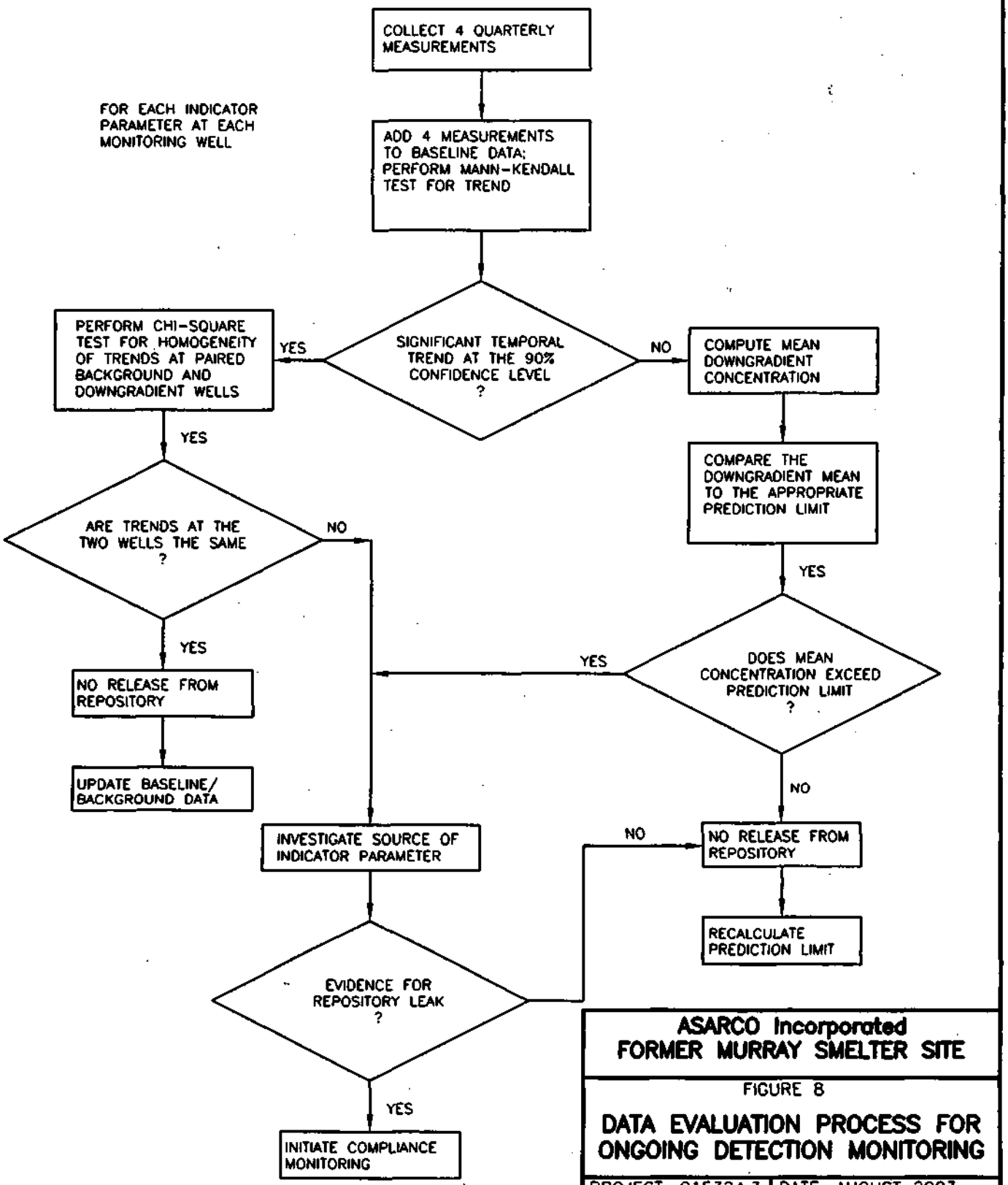

ASARCO Incorporated
FORMER MURRAY SMELTER SITE

FIGURE 8

DATA EVALUATION PROCESS FOR ONGOING DETECTION MONITORING

PROJECT: 015324.3	DATE: AUGUST 2003	
REV:	BY: SCG	CHECKED: KJT

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Figure 9: Temporal Trend Plot for Arsenic at Compliance Well MW-5D

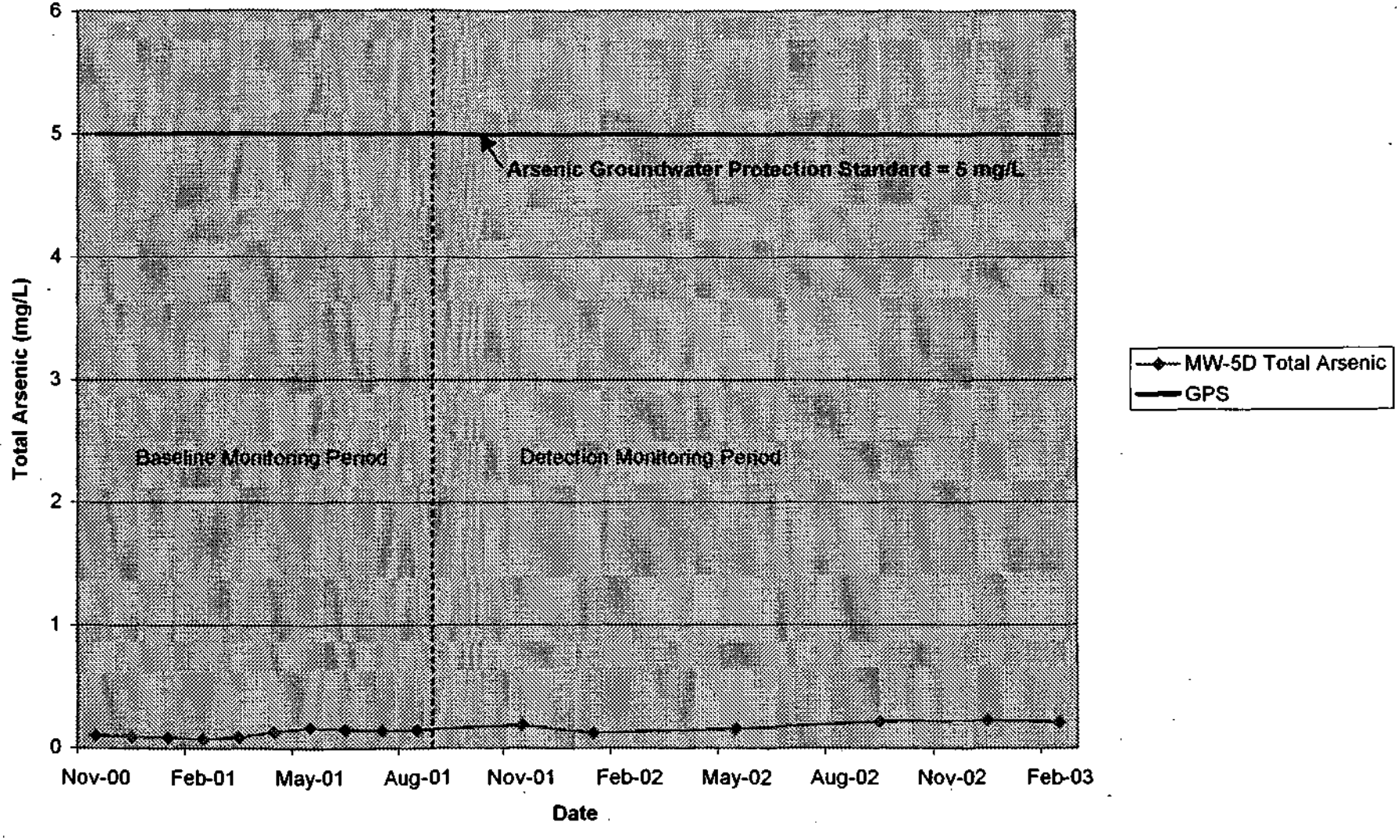


Figure 10: Temporal Trend Plot for Sulfate at Compliance Well MW-5D

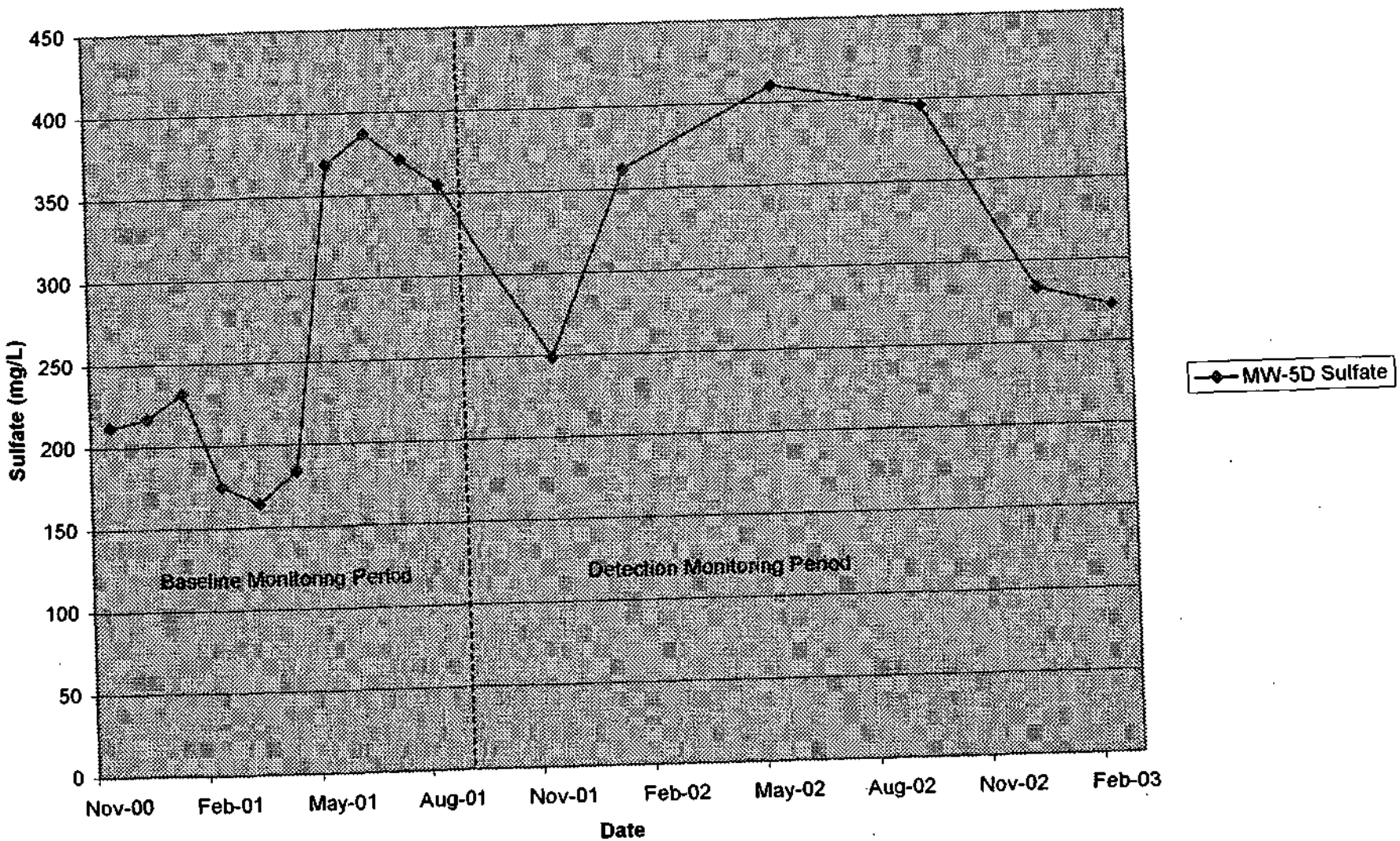


Figure 11: Temporal Trend Plot for Cadmium at Compliance Well MW-5D

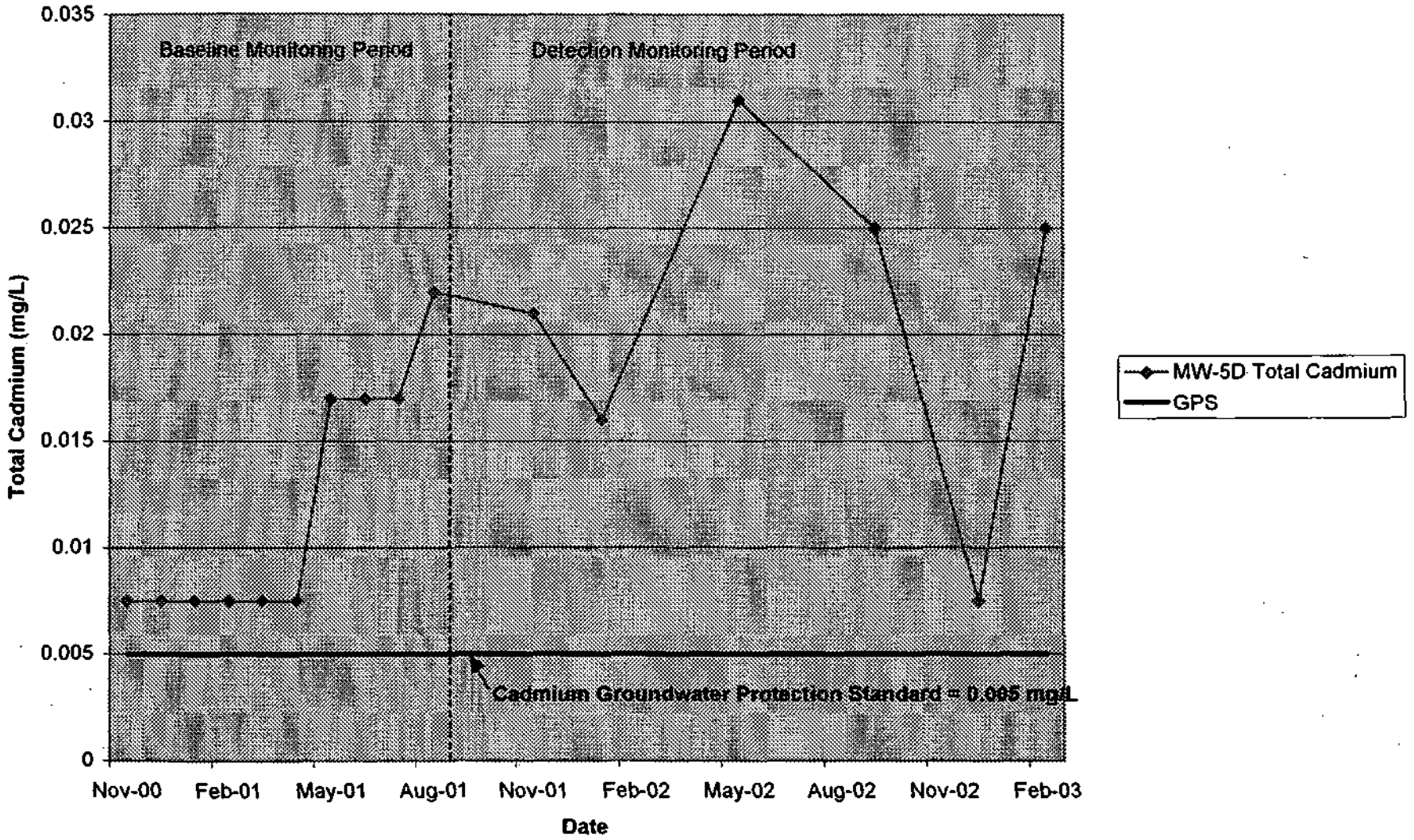
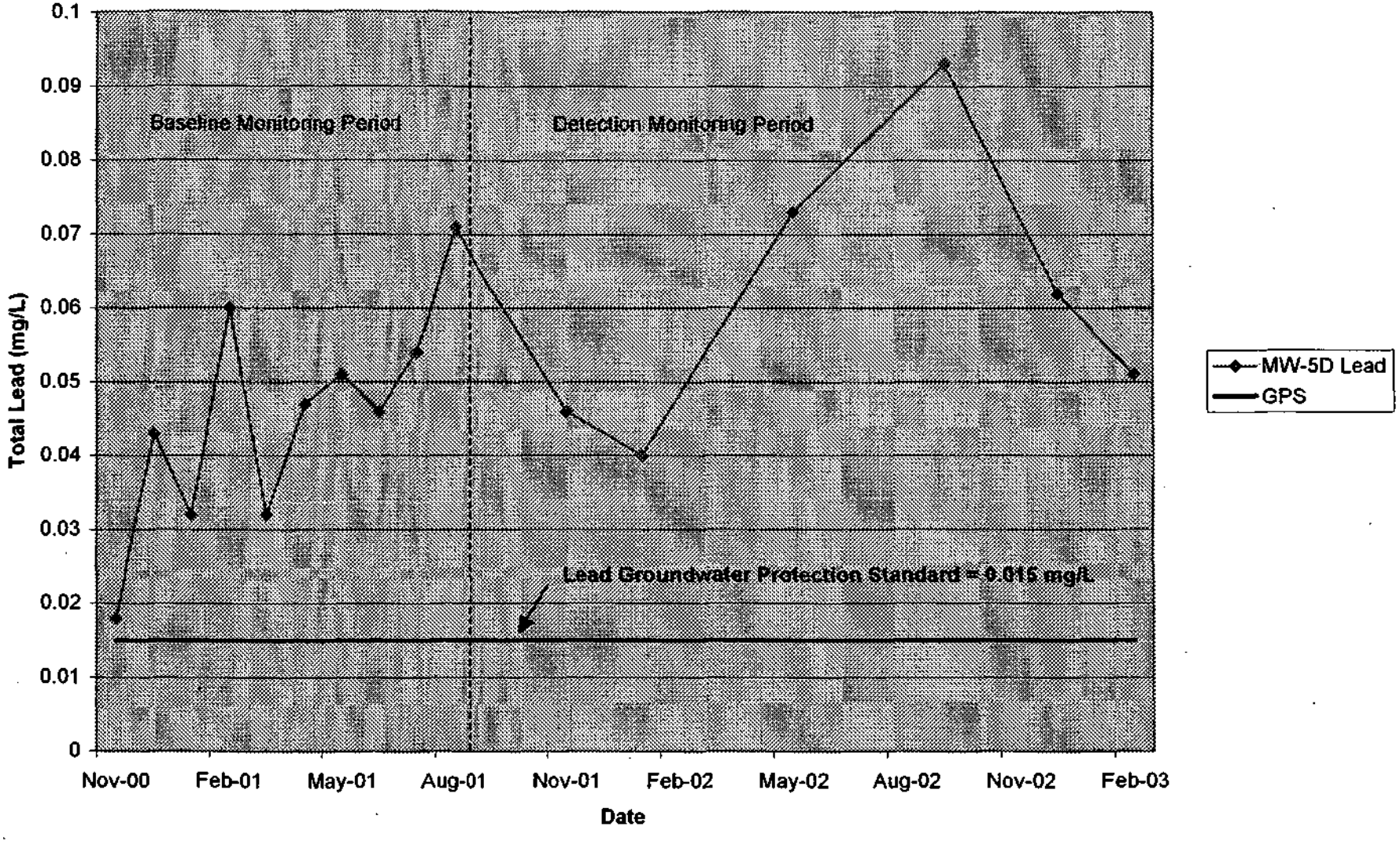
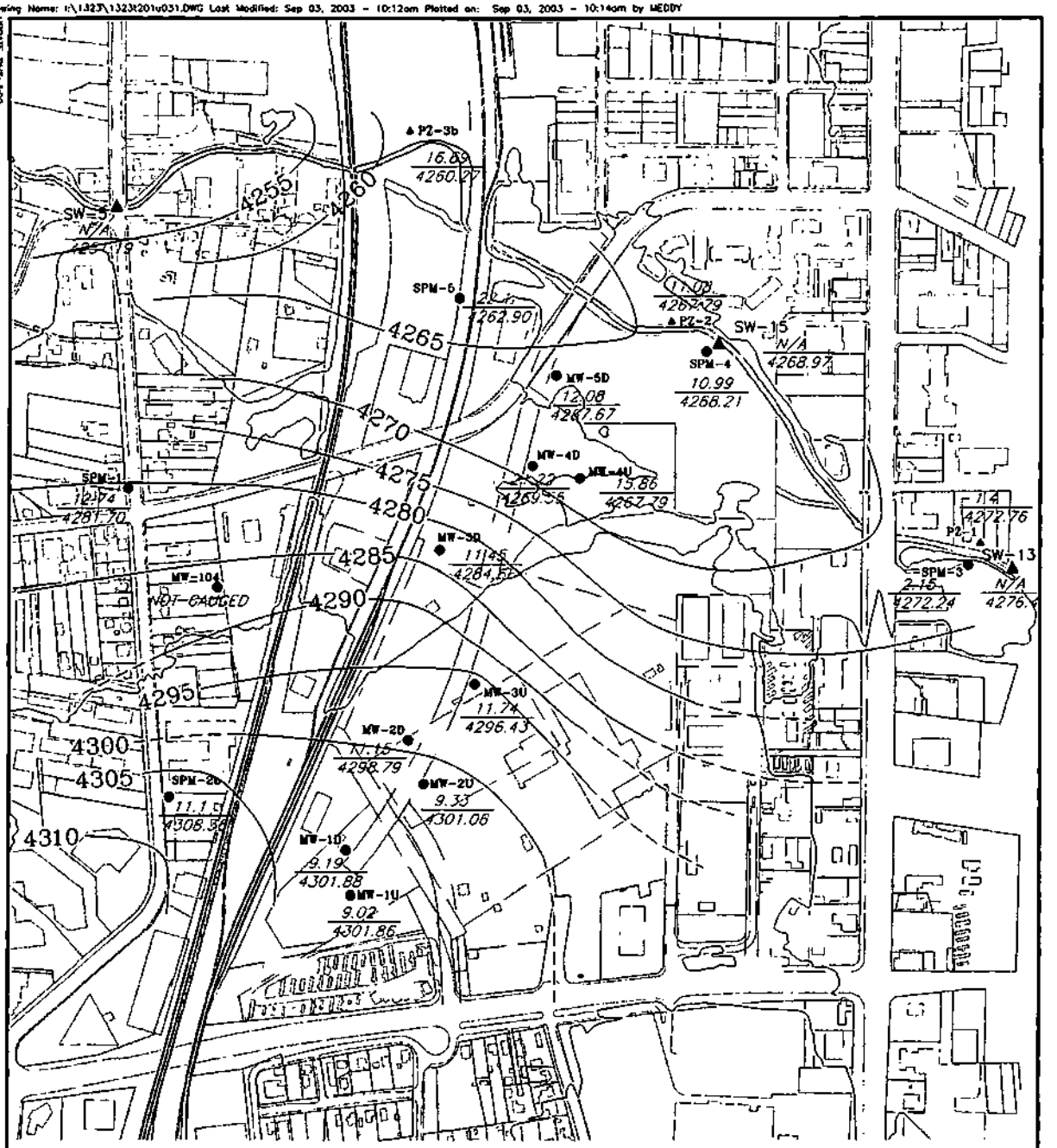


Figure 12: Temporal Trend Plot for Lead at Compliance Well MW-5D





LEGEND:

MW-1D ● SHALLOW AQUIFER MONITOR WELL LOCATION

▲ PZ-2 PIEZOMETER LOCATION

SW-13 ▲ SURFACE WATER (LITTLE COTTONWOOD CREEK) MONITOR & SAMPLE LOCATION

4300 ELEVATION OF POTENTIOMETRIC SURFACE (CONTOUR INTERVAL: 5 FEET) (FEET ABOVE MEAN SEA LEVEL) DASHED WHERE INFERRED

12.45 / 4292.34 DEPTH TO WATER (FEET BELOW MEASURING POINT) / WATER LEVEL ELEVATION (FEET ABOVE MEAN SEA LEVEL)

NORTH

SCALE
1"=400'
400 0 400
(Approximate Only)

NOTE: BASE MAP FROM McCULLEY, FRICK AND GILMAN, INC. (MFG).

ASARCO INCORPORATED FORMER MURRAY SMELTER SITE MURRAY, UTAH	POTENTIOMETRIC MAP FOR THE SHALLOW AQUIFER MAY 2002	FIGURE 13

Table 1

Arsenic Statistical Summary for Repository Wells During Baseline Monitoring

Date	MW-1D	MW-1U	MW-2D	MW-2U	MW-2U (Log)	MW-3D	MW-3D (Log)	MW-3U	MW-3U (Log)	MW-4D	MW-4U	MW-4D & MW-4U
11/7/00	4.58	13.94	1.834	0.007	-2.155	0.0025	-2.602	0.0025	-2.602	0.008	0.017	
12/11/00	4.083	13.917	1.659	0.007	-2.155	0.0025	-2.602	0.006	-2.222	0.013	0.018	
1/9/01	4.212	14.479	1.487	0.006	-2.222	0.0025	-2.602	0.006	-2.222	0.013	0.017	
2/3/01	4.172	14.15	1.49	0.007	-2.155	0.005	-2.301	0.006	-2.222	0.014	0.017	
3/1/01	4.04	14.431	1.547	0.007	-2.155	0.0025	-2.602	0.006	-2.222	0.014	0.016	
4/5/01	3.233	13.64	1.945	0.0025	-2.602	0.0025	-2.602	0.0025	-2.602	0.011	0.013	
5/8/01	3.374	12.8	2.67	0.007	-2.155	0.0025	-2.602	0.007	-2.155	0.015	0.015	
6/12/01	4.403	12.96	3.4	0.005	-2.301	0.0025	-2.602	0.006	-2.222	0.015	0.01	
7/10/01	4.423	13.24	0.0025	4.241	0.627	0.0025	-2.602	0.0025	-2.602	0.012	0.013	
8/15/01	4.238	12.72	3.737	0.0025	-2.602	0.0025	-2.602	0.005	-2.301	0.014	0.013	
Minimum	3.233	12.72	0.0025	0.0025	-2.602	0.0025	-2.602	0.0025	-2.602	0.008	0.01	
Maximum	4.58	14.479	3.737	4.241	0.627	0.005	-2.301	0.007	-2.155	0.015	0.018	
Mean	4.0758	13.6277	1.97715	0.4292	-1.987	0.00275	-2.572	0.00495	-2.337	0.0129	0.0149	0.014
Standard Deviation	0.4397	0.6608	1.0691	1.3393	0.936	0.0008	0.095	0.0018	0.186	0.0021	0.0026	0.003
Shapiro-Wilk	0.850	0.922	0.921	0.361	0.522	0.360	0.360	0.769	0.721	0.857	0.905	0.960
5% Critical Value	0.842	0.842	0.842	0.842	0.842	0.842	0.842	0.842	0.842	0.842	0.842	0.905
Distribution	Normal	Normal	Normal	Nonparametric		Nonparametric		Nonparametric		Normal	Normal	Normal
95 UCL	4.33	14.01	2.60	4.241		0.005		0.007		0.014	0.016	
90/95 UTL	5.11	15.18	4.49	4.241		0.005		0.007		0.022	0.021	
Mann-Whitney, p	0.0002		0.016			0.005				0.100		
Upgradient/Down Gradient Well Pairs Significantly Different?	Yes		Yes			Yes				No		
Well Pair 90/95 UTL	5.11		4.49			0.005				0.019		
$t_{(n-1,1,0.95)}$	1.83		1.83			1.83				1.73		
Well Pair 95 UPL	4.92		4.03			0.005				0.018		

Notes: (1) Concentrations are in mg/L.

(2) Detection limit for arsenic was 0.005 mg/L. Where concentrations were below detection limits, half the detection limit value was used for statistical analysis, as shown in the table.

Table 2

Sulfate Statistical Summary for Repository Wells During Baseline Monitoring

Date	MW-1D	MW-1D (Log)	MW-1U	MW-2D	MW-2U	MW-2D & MW-2U	MW-3D	MW-3U	MW-4D	MW-4D (log)	MW-4U	MW-4D & MW-4U
11/7/00	935	2.971	799	485	528		501	207	378	2.577	372	
12/11/00	1003	3.001	791	454	508		658	175	371	2.569	347	
1/9/01	989	2.995	768	404	492		700	164	376	2.575	346	
2/3/01	955	2.980	782	461	478		714	178	388	2.589	340	
3/1/01	933	2.970	731	431	516		662	194	352	2.547	331	
4/5/01	1025	3.011	763	420	525		731	191	361	2.558	315	
5/8/01	1164	3.066	778	516	602		829	204	376	2.575	313	
6/12/01	972	2.988	860	557	546		788	214	378	2.577	390	
7/10/01	930	2.968	737	529	469		616	194	324	2.511	388	
8/15/01	925	2.966	757	557	570		612	203	376	2.575	345	
Minimum	925	2.966	731	404	469		501	164	324	2.511	313	
Maximum	1164	3.066	860	557	602		829	214	388	2.589	390	
Mean	983.1	2.992	776.6	481.4	523.4	502.4	681.1	192.4	368	2.565	348.7	239.7551
Standard Deviation	72.144	0.030	36.494	56.149	41.072	52.504	94.032	15.813	18.385	0.023	27.113	171.746
Shapiro-Wilk	0.774	0.799	0.908	0.935	0.965	0.984	0.978	0.952	0.803	0.787	0.920	0.915
5% Critical Value	0.842	0.842	0.842	0.842	0.842	0.905	0.842	0.842	0.842	0.842	0.842	0.905
Distribution	Nonparametric		Normal	Normal	Normal	Normal	Normal	Normal	Nonparametric		Normal	Normal
95 UCL	1164		797.8	514.0	547.2		735.6	201.6	388		364.4	
90/95 UTL	1164		862.5	613.6	620.1		902.5	229.6	388		412.5	
Mann-Whitney, p	0.0002			0.13			0.0002		0.111			
Upgradient/Down Gradient Well Pairs Significantly Different?	Yes			No			Yes		No			
Well Pair 90/95 UTL	1164			603.5			902.5		405.8			
$t_{(n-1,1,0.95)}$	1.83			1.73			1.83		1.73			
Well Pair 95 UPL	1164			595			903		544			

Note: (1) Concentrations are in mg/L.

Table 3

Statistical Summary for Compliance Well MW-5D During Baseline Monitoring

Date	Arsenic	Sulfate	Barium	Cadmium	Chromium	Copper	Lead	Mercury	Selenium	Silver	Zinc
11/7/00	0.101	212	0.319	0.0075	0.025	0.025	0.018	0.00025	0.0005	0.0125	0.135
12/11/00	0.092	217	0.255	0.0075	0.025	0.025	0.043	0.00025	0.017	0.0125	0.395
1/9/01	0.085	232	0.198	0.0075	0.025	0.025	0.032	0.00025	0.01	0.0125	0.51
2/3/01	0.075	175	0.128	0.0075	0.025	0.025	0.060	0.00025	0.021	0.0125	0.469
3/1/01	0.089	164	0.123	0.0075	0.025	0.025	0.032	0.00025	0.012	0.0125	0.518
4/5/01	0.129	184	0.182	0.0075	0.025	0.025	0.047	0.00025	0.00025	0.0125	0.695
5/8/01	0.165	369	0.222	0.017	0.025	0.025	0.051	0.00025	0.00025	0.0125	0.834
6/12/01	0.152	387	0.234	0.017	0.025	0.025	0.046	0.00025	0.015	0.0125	0.68
7/11/01	0.144	371	0.215	0.017	0.025	0.025	0.054	0.0005	0.019	0.0125	0.645
8/15/01	0.148	355	0.217	0.022	0.025	0.025	0.071	0.00025	0.02	0.0125	0.733
Minimum	0.075	164	0.123	0.0075	0.025	0.025	0.018	0.00025	0.00025	0.0125	0.135
Maximum	0.165	387	0.319	0.022	0.025	0.025	0.071	0.0005	0.021	0.0125	0.834
Mean	0.118	266.6	0.2093	0.0118	0.025	0.025	0.0454	0.000275	0.0115	0.0125	0.5614
Standard Deviation	0.0330	91.9386	0.0577	0.0057	0.0000	0.0000	0.0152	0.0001	0.0084	0.0000	0.2014
Shapiro-Wilk	0.902	0.829	0.947	0.728	-	-	0.969	-	0.886	-	0.947
5% Critical Value	0.829	0.829	0.829	0.829	-	-	0.829	-	0.829	-	0.829
Distribution	Normal	Normal	Normal	Nonparametric	Nonparametric	Nonparametric	Normal	Nonparametric	Normal	Nonparametric	Normal
95 UCL	0.142	332	0.251	0.022	0.025	0.025	0.055	0.0005	0.017	0.0125	0.715
90/95 UTL	0.196	483	0.058	0.022	0.025	0.025	0.088	0.0005	0.03	0.0125	1.05
Groundwater Protection Standards	5	-	2.0	0.005	0.1	1.3	0.015	0.002	0.05	0.1	5
95 UCL Exceeds GPS?	No	No	No	Yes	No	No	Yes	No	No	No	No

Notes: (1) Concentrations are in mg/L.

(2) Where concentrations were below detection limits, a value of half the detection limit was used in the statistical analysis.

Table 4

Arsenic Statistical Summary for Repository Wells During Detection Monitoring (Four Quarters)

Date	MW-1D	MW-1U	MW-2D	MW-2U	MW-3D	MW-3U	MW-4D	MW-4U
Nov-01	4.855	14.185	2.312	0.0025	0.0025	0.0025	0.015	0.015
Jan-02	3.626	11.66	2.634	0.0025	0.0025	0.0025	0.014	0.013
May-02	3.969	12.3	4.447	0.0025	0.0025	0.0025	0.016	0.012
Sep-02	4.128	10.62	6.808	0.018	0.012	0.011	0.019	0.019
Mean	4.1945	12.19125	4.05025	0.006875	0.00488	0.004625	0.016	0.01475
Mann-Kendall Test for Upward Trend	Neg.	Neg.	Pos.	Neg.	Neg.	Neg.	Neg.	Neg.
Baseline UPL	4.92		4.03		0.005		0.018	
Mean > UPL?	No		Yes		No		No	

Mann-Kendall Tests

	Time	1	2	3	4	# of + Signs	# of - Signs			
MW-1D	Data	4.855	3.626	3.969	4.128					
			-1.029	-0.886	-0.727	0	3			
				0.143	0.302	2	0			
					0.159	1	0			
								S	Probability	Probability > 0.10 therefore
						3	3	0	0.625	No Upward Trend @ 90% Confidence
MW-1U	Time	1	2	3	4	# of + Signs	# of - Signs			
	Data	14.185	11.66	12.3	10.62					
			-2.525	-1.885	-3.565	0	3			
				0.64	-1.04	1	1			
					-1.68	0	1			
								S	Probability	Probability > 0.10 therefore
						1	5	-4	Neg.	No Upward Trend @ 90% Confidence
MW-2D	Time	1	2	3	4	# of + Signs	# of - Signs			
	Data	2.312	2.634	4.447	6.808					
			0.322	2.135	4.496	3	0			
				1.813	4.174	2	0			
					2.361	1	0			
								S	Probability	Probability < 0.10 therefore
						6	0	6	0.042	Possible Upward Trend @ 90% Confidence
MW-2U	Time	1	2	3	4	# of + Signs	# of - Signs			
	Data	0.0025	0.0025	0.0025	0.018					
			0	0	0.0155	1	0			
				0	0.0155	1	0			
					0.0155	1	0			
								S	Probability	Probability > 0.10 therefore
						3	0	3	0.271	No Upward Trend @ 90% Confidence
MW-3D	Time	1	2	3	4	# of + Signs	# of - Signs			
	Data	0.0025	0.0025	0.0025	0.012					
			0	0	0.0095	1	0			
				0	0.0095	1	0			
					0.0095	1	0			
								S	Probability	Probability > 0.10 therefore
						3	0	3	0.271	No Upward Trend @ 90% Confidence
MW-3U	Time	1	2	3	4	# of + Signs	# of - Signs			
	Data	0.0025	0.0025	0.0025	0.011					
			0	0	0.0085	1	0			
				0	0.0085	1	0			
					0.0085	1	0			
								S	Probability	Probability > 0.10 therefore
						3	0	3	0.271	No Upward Trend @ 90% Confidence
MW-4D	Time	1	2	3	4	# of + Signs	# of - Signs			
	Data	0.015	0.014	0.016	0.019					
			-0.001	0.001	0.004	2	1			
				0.002	0.005	2	0			
					0.003	1	0			
								S	Probability	Probability > 0.10 therefore
						5	1	4	0.167	No Upward Trend @ 90% Confidence
MW-4U	Time	1	2	3	4	# of + Signs	# of - Signs			
	Data	0.015	0.013	0.012	0.019					
			-0.002	-0.003	0.004	2	1			
				-0.001	0.006	1	1			
					0.007	1	0			
								S	Probability	Probability > 0.10 therefore
						4	2	2	0.375	No Upward Trend @ 90% Confidence

Notes: (1) Concentrations in mg/L.

(2) Detection limit for arsenic was 0.005 mg/L. Where concentrations were below detection limit, half the detection limit value was used for statistical analysis.

Table 6

Sulfate Statistical Summary for Repository Wells During Detection Monitoring (Four Quarters)

Date	MW-1D	MW-1U	MW-2D	MW-2U	MW-3D	MW-3U	MW-4D	MW-4U
Nov-01	891	654	325	524	521	184	331	312
Jan-02	984	797	301	455	593	230	390	314
May-02	886	847	297	582	494	232	350	320
Sep-02	1027	993	559	597	568	227	409	343
Mean	947	822.75	370.5	539.5	544	218.25	370	322.25
Mann-Kendall Test for Upward Trend	Neg.	Pos.	Neg.	Neg.	Neg.	Neg.	Neg.	Pos.
Baseline UPL	1184		595		903		544	
Mean > UPL?	No		No		No		No	

Mann-Kendall Tests

MW-1D	Time	1	2	3	4	# of +	# of -			
	Data	891	984	886	1027	Signs	Signs			
			93	-5	136	2	1			
				-98	43	1	1			
					141	1	0			
								S	Probability	Probability > 0.10 therefore
						4	2	2	0.375	No Upward Trend @ 90% Confidence

MW-1U	Time	1	2	3	4	# of +	# of -			
	Data	654	797	847	993	Signs	Signs			
			143	193	339	3	0			
				50	196	2	0			
					146	1	0			
								S	Probability	Probability < 0.10 therefore
						6	0	6	0.042	Possible Upward Trend @ 90% Confidence

MW-2D	Time	1	2	3	4	# of +	# of -			
	Data	325	301	297	559	Signs	Signs			
			-24	-28	234	1	2			
				-4	258	1	1			
					262	1	0			
								S	Probability	Probability > 0.10 therefore
						3	3	0	0.625	No Upward Trend @ 90% Confidence

MW-2U	Time	1	2	3	4	# of +	# of -			
	Data	524	455	582	597	Signs	Signs			
			-69	58	73	2	1			
				127	142	2	0			
					15	1	0			
								S	Probability	Probability > 0.10 therefore
						5	1	4	0.167	No Upward Trend @ 90% Confidence

MW-3D	Time	1	2	3	4	# of +	# of -			
	Data	521	593	494	568	Signs	Signs			
			72	-27	47	2	1			
				-99	-25	0	2			
					74	1	0			
								S	Probability	Probability > 0.10 therefore
						3	3	0	0.625	No Upward Trend @ 90% Confidence

MW-3U	Time	1	2	3	4	# of +	# of -			
	Data	184	230	232	227	Signs	Signs			
			46	48	43	3	0			
				2	-3	1	1			
					-5	0	1			
								S	Probability	Probability > 0.10 therefore
						4	2	2	0.375	No Upward Trend @ 90% Confidence

MW-4D	Time	1	2	3	4	# of +	# of -			
	Data	331	390	350	409	Signs	Signs			
			59	19	78	3	0			
				-40	19	1	1			
					59	1	0			
								S	Probability	Probability > 0.10 therefore
						5	1	4	0.167	No Upward Trend @ 90% Confidence

MW-4U	Time	1	2	3	4	# of +	# of -			
	Data	312	314	320	343	Signs	Signs			
			2	8	31	3	0			
				6	29	2	0			
					23	1	0			
								S	Probability	Probability < 0.10 therefore
						6	0	6	0.042	Possible Upward Trend @ 90% Confidence

Note: (1) Concentrations in mg/L.

Table 6

Chi-square Test for Homogenity for Paired Wells MW-2D and MW-2U (Four Quarters)

Null Hypothesis: If there are trends in the MW-2D and MW-2U data sets, then the data sets are trending in the same direction.

MW-2D			MW-2U		
S_1 =	6	(Mann-Kendall)	S_2 =	3	(Mann-Kendall)
$VAR(S_1)$ =	8.67		$VAR(S_2)$ =	5	
Z_1 =	1.7		Z_2 =	0.89	

Chi^2_{homog}	3.35
Critical value = (α = 0.05)	2.71

Chi^2_{homog} > Critical Value. Therefore, null hypothesis is rejected. Data sets are not trending in the same direction.

Table 7

Arsenic Statistical Summary for Well MW-2D During Detection Monitoring (Six Quarters)

Date	MW-2D
Nov-01	2.312
Jan-02	2.634
May-02	4.447
Sep-02	6.808
Dec-02	5.289
Feb-03	3.394

Mean	4.15

Mann-Kendall Test for Upward Trend	Neg.

Mann-Kendall Tests

MW-2D	Time	1	2	3	4	5	6	# of +	# of -			
	Data	2.312	2.634	4.447	6.808	5.289	3.394	Signs	Signs			
			0.322	2.135	4.496	2.977	1.082	5	0			
				1.813	4.174	2.655	0.76	4	0			
					2.361	0.842	-1.053	2	1			
						-1.519	-3.414	0	2			
							-1.895	0	1			
										S	Probability	Probability > 0.10 therefore
								11	4	7	0.136	No Upward Trend @ 90% Confidence

Note: Concentrations in mg/L.

Table 8

Data Summary for Compliance Well MW-5D

Date	Arsenic		Sulfate		Barium		Cadmium			Chromium		Copper		Lead		Mercury		Selenium		Silver		Zinc
	Data	GPS	Data	GPS	Data	GPS	Data	P	GPS	Data	GPS	Data	GPS	Data	GPS	Data	GPS	Data	GPS	Data	GPS	Data
Nov-00	0.101	5	212	-	0.319	2.0	0.0075	-2	0.005	0.025	0.1	0.025	1.3	0.018	0.015	0.00025	0.002	0.0005	0.05	0.0125	0.1	0.135
Dec-00	0.092	5	217	-	0.255	2.0	0.0075	-2	0.005	0.025	0.1	0.025	1.3	0.043	0.015	0.00025	0.002	0.017	0.05	0.0125	0.1	0.385
Jan-01	0.085	5	232	-	0.198	2.0	0.0075	-2	0.005	0.025	0.1	0.025	1.3	0.032	0.015	0.00025	0.002	0.01	0.05	0.0125	0.1	0.51
Feb-01	0.075	5	175	-	0.126	2.0	0.0075	-2	0.005	0.025	0.1	0.025	1.3	0.060	0.015	0.00025	0.002	0.021	0.05	0.0125	0.1	0.469
Mar-01	0.089	5	184	-	0.123	2.0	0.0075	-2	0.005	0.025	0.1	0.025	1.3	0.032	0.015	0.00025	0.002	0.012	0.05	0.0125	0.1	0.518
Apr-01	0.129	5	184	-	0.182	2.0	0.0075	-2	0.005	0.025	0.1	0.025	1.3	0.047	0.015	0.00025	0.002	0.00025	0.05	0.0125	0.1	0.695
May-01	0.165	5	369	-	0.222	2.0	0.017	-2	0.005	0.025	0.1	0.025	1.3	0.051	0.015	0.00025	0.002	0.00025	0.05	0.0125	0.1	0.834
Jun-01	0.152	5	387	-	0.234	2.0	0.017	-2	0.005	0.025	0.1	0.025	1.3	0.048	0.015	0.00025	0.002	0.015	0.05	0.0125	0.1	0.66
Jul-01	0.144	5	371	-	0.215	2.0	0.017	-2	0.005	0.025	0.1	0.025	1.3	0.054	0.015	0.0005	0.002	0.019	0.05	0.0125	0.1	0.645
Aug-01	0.148	5	355	-	0.217	2.0	0.022	-2	0.005	0.025	0.1	0.025	1.3	0.071	0.015	0.00025	0.002	0.02	0.05	0.0125	0.1	0.733
Nov-01	0.188	5	249	-	0.277	2.0	0.021	0	0.005	0.025	0.1	0.025	1.3	0.046	0.015	0.0005	0.002	0.011	0.05	0.0125	0.1	0.395
Jan-02	0.124	5	362	-	0.23	2.0	0.018	0	0.005	0.025	0.1	0.025	1.3	0.04	0.015	0.0005	0.002	0.02	0.05	0.0125	0.1	0.414
May-02	0.153	5	410	-	0.159	2.0	0.031	0	0.005	0.025	0.1	0.025	1.3	0.073	0.015	0.0005	0.002	0.035	0.05	0.0125	0.1	0.529
Sep-02	0.217	5	398	-	0.169	2.0	0.025	0	0.005	0.025	0.1	0.025	1.3	0.093	0.015	0.0005	0.002	0.024	0.05	0.0125	0.1	0.388
Dec-02	0.224	5	283	-	0.196	2.0	0.0075	1	0.005	0.025	0.1	0.025	1.3	0.062	0.015	0.0005	0.002	0.011	0.05	0.0125	0.1	0.296
Feb-03	0.212	5	272	-	0.183	2.0	0.025	1	0.005	0.025	0.1	0.025	1.3	0.051	0.015	0.005	0.002	0.036	0.05	0.0125	0.1	0.219

Notes: (1) Concentrations are in mg/L.
(2) Where concentrations were below detection limits, a value of half the detection limit was used in the statistical analysis.

Table 9

Arsenic Statistical Summary for Boundary Wells in the Shallow Aquifer

	Well ID Area						
Date	SPM-1 West	SPM-1 (Log)	SPM-2b West	SPM-2 (Log)	SPM-3 North	SPM-4 North	SPM-5 North
Jan-01	0.005	-2.301	0.0025	-2.602	0.032	0.099	0.31
May-01	0.0025	-2.602	0.0025	-2.602	0.022	0.082	0.27
Aug-01	0.009	-2.046	0.007	-2.155	0.032	0.069	0.28
Nov-01	0.0025	-2.602	NS	NS	0.039	0.09	0.29
Jan-02	0.0025	-2.602	NS	NS	0.033	0.065	0.28
May-02	0.006	-2.222	0.0025	-2.602	0.027	0.078	0.38
Sep-02	0.0025	-2.602	0.0025	-2.602	0.048	0.093	0.31
Dec-02	0.005	-2.301	0.0025	-2.602	0.066	0.089	0.29
Feb-03	0.0025	-2.602	0.0025	-2.602	0.039	0.068	0.32
Min	0.0025	-2.602	0.0025	-2.602	0.022	0.065	0.27
Max	0.009	-2.046	0.007	-2.155	0.066	0.099	0.38
Mean	0.00417	-2.431	0.00314	-2.538	0.03756	0.08144	0.30333
Standard Deviation	0.00229	0.21571	0.00170	0.16901	0.01303	0.01220	0.03317
Shapiro-Wilks, w	0.773	0.783	0.457	0.457	0.888	0.937	0.83
5% Critical Value	0.829	0.829	0.829	0.829	0.829	0.829	0.829
Distribution	Nonparametric		Nonparametric		Normal	Normal	Normal
90/95 UTL	0.009		0.007		0.0695	0.111	0.384
Performance Standard	0.05		0.05		5	5	5
UTL < Performance Standard	Yes		Yes		Yes	Yes	Yes

Notes: (1) Concentrations in mg/L.

(2) For concentrations below the 0.005 mg/l detection limit, half the detection limit value is used in statistical analysis.

Table 10

Arsenic Statistical Summary for Wells in the Intermediate Aquifer

	Well ID				Logged Data			
Date	IMP-1	IMP-2	IMP-3	IMP-4	IMP-1	IMP-2	IMP-3	IMP-4
Jan-01	0.0025	0.0025	0.013	0.021	-2.60206	-2.60206	-1.88606	-1.6777807
May-01	0.0025	0.0025	0.006	0.023	-2.60206	-2.60206	-2.22185	-1.6382722
Aug-01	0.0025	0.007	0.006	0.029	-2.60206	-2.1549	-2.22185	-1.537602
Nov-01	0.0025	0.0025	0.0025	0.026	-2.60206	-2.60206	-2.60206	-1.5850267
Jan-02	0.0025	0.0025	0.0025	0.024	-2.60206	-2.60206	-2.60206	-1.6197888
May-02	0.0025	0.0025	0.0025	0.025	-2.60206	-2.60206	-2.60206	-1.60206
Sep-02	0.0025	0.0025	0.0025	0.026	-2.60206	-2.60206	-2.60206	-1.5850267
Dec-02	0.0025	0.0025	0.0025	0.018	-2.60206	-2.60206	-2.60206	-1.7447275
Feb-03	0.0025	0.0025	0.0025	0.016	-2.60206	-2.60206	-2.60206	-1.79588
Min	0.0025				-2.602059991			
Max	0.029				-1.537602002			
Mean	0.00826				-2.30884			
Standard Deviation	0.00913				0.42228			
Shapiro-Wilks, w	0.655				0.666			
5% Critical Value	0.935				0.935			
Distribution	Nonparametric							
90/95 UTL	0.029							
Criteria	0.05							
UTL < Criteria	Yes							

Notes: (1) Concentrations in mg/L.
(2) For concentrations below the 0.005 mg/L detection limit, half the detection limit value is used in statistical analysis.

Table 11

Data Summary for Surface Water Monitoring Location SW-5

Sample Date	Dissolved Arsenic (III) (mg/L)	Dissolved Arsenic (mg/L)
Jan-01	< 0.02	0.11
May-01	0.009	0.016
Jan-02	0.023	0.064
May-02	< 0.005	< 0.005
Feb-03	< 0.005	0.017
Surface Water Quality Criteria (mg/L)		
Aquatic Life Criteria	0.19 (4-day)	-
	0.36 (1-day)	-
Agricultural Use Standard	-	0.10

TABLE 12
Arsenic Statistical Summary for Wells Used in Monitoring Natural Attenuation

Date	MW-1D	MW-2D	MW-3D	MW-104
Jan-01	4.212	1.487	0.0025	0.0025
Aug-01	4.238	3.737	0.0025	0.007
Jan-02	3.826	2.634	0.0025	0.0025
Sep-02	4.128	6.808	0.012	0.0025
Feb-03	3.915	3.394	0.0025	-
Mann-Kendall Test for Upward Trend	Neg.	Neg.	Neg	Neg.

Mann-Kendall Tests

MW-1D	Time	1	2	3	4	5	# of +	# of -			
	Data	4.212	4.238	3.826	4.128	3.915	Signs	Signs			
			0.026	-0.386	-0.084	-0.297	1	2			
				-0.412	-0.11	-0.323	0	2			
					0.302	0.089	1	0			
						-0.213	0	1			
									S	Probability	
							2	5	-3	Neg.	No Upward Trend @ 90% Confidence
MW-2D	Time	1	2	3	4	5	# of +	# of -			
	Data	1.487	3.737	2.634	6.808	3.394	Signs	Signs			
			2.25	1.147	5.321	1.907	3	0			
				-1.103	3.071	-0.343	1	1			
					4.174	0.76	1	0			
						-3.414	0	1			
									S	Probability	Probability > 0.10 therefore
							5	2	3	0.271	No Upward Trend @ 90% Confidence
MW-3D	Time	1	2	3	4	5	# of +	# of -			
	Data	0.0025	0.0025	0.0026	0.012	0.0025	Signs	Signs			
			0	0	0.0095	0	1	0			
				0	0.0095	0	1	0			
					0.0095	0	1	0			
						-0.0095	0	1			
									S	Probability	Probability > 0.10 therefore
							3	1	2	0.375	No Upward Trend @ 90% Confidence
MW-104	Time	1	2	3	4		# of +	# of -			
	Data	0.0025	0.007	0.0025	0.0025		Signs	Signs			
			0.0045	0	0		1	0			
				-0.0045	-0.0045		0	2			
					0		0	0			
									S	Probability	
							1	2	-1	Neg.	No Upward Trend @ 90% Confidence